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THE

Progressive Fish-Culturist

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TABLE OF CONTENTS

	Page
Threshold Temperatures for the Normal Development of Chinook Salmon Eggs -- Bobby D. Combs and Roger E. Burrows	3
Histopathology of Fish: V. Gill Disease -- E. M. Wood and W. T. Yasutake	7
Blue-Sac Disease Investigations: Microbiology and Laboratory Induction -- Ken Wolf	14
A Chemical Comparison of Hatchery and Wild Brook Trout -- A. M. Phillips, Jr., D. R. Brockway, F. E. Lovelace, and H. A. Podoliak	19
Production During Intensive Carp Culture in Japan -- N. Y. Kawamoto	26
Fish Foods Purchased for Federal Hatcheries in 1955, Compared With 1945 and 1949 -- William Hagen, Jr.	32
A Method of Using an Anesthetic in Marking Fins -- Wallace F. Hublou	40
Professionalism in Fishery Biology -- Roger W. Bachmann	44
Who Wants a Biologist? Two Years of Private Consulting Service -- E. A. Seaman	47

Items

Simplified Transport for Smaller Numbers of Salmonids	13
The Stoneroller in the Smokies	25

Items (continued) Page

Neutralizing Electrostatic Charge on Rolling-Mill Scale Press ---------- 31
Various Drugs As Aids in Spawning Rainbow Trout ---------- 39

From Publications

Review:
Die Electrofischerei (Electrofishing), by H. W. Denzer ---------- 43

THRESHOLD TEMPERATURES FOR THE NORMAL DEVELOPMENT OF CHINOOK SALMON EGGS

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EXPERIMENTS TO DETERMINE THE THRESHOLD TEMPERATURES FOR THE NORMAL DEVELOPMENT OF CHINOOK SALMON (Oncorhynchus tshawytscha) EGGS have been made at the Salmon-Cultural Laboratory at Entiat, Washington. By use of controlled-temperature apparatus, the effect of constant incubating temperatures on the development of chinook salmon eggs has been ascertained.

Equipment and Techniques

Special equipment and techniques were devised in order to conduct these experiments. Conditions were comparable for all three experiments.

The controlled-temperature apparatus included both a refrigeration device and a water heater in order that a water supply at any temperature between 33° and 70° F. could be obtained. Thermostatically controlled mixing valves regulated the flow of the heated and cooled water into the small wooden troughs in which the eggs were incubated. These valves were sufficiently sensitive to maintain the set temperature within 1° F. Each valve supplied water to two troughs so that experiments could be run in duplicate. A complete temperature record of each experiment was maintained by use of recording thermometers.

Chinook salmon eggs from a single day's take were selected for the experiments. The eggs were distributed equally and at random into egg baskets with a 100-egg sampler. These baskets were placed in the constant temperature troughs within a few hours after spawning and fertilization. Between 600 and 1,000 eggs were stocked into each basket, depending on the number available for the experiment.

A complete hatching record was maintained for each lot of eggs. From the time the first fry appeared in a tray, daily counts were made of the fry or remaining eggs until hatching was completed.

Mortality was the criterion used for establishing the threshold temperatures. A significant rise in mortality above the expected level as determined by analysis of variance indicated that normal development had not taken place. As the incubation temperature was the only variable in the experiments, the increase in mortality was attributed to this factor.

Design of Experiments

Three separate but related experiments were included in this study. Each experiment was designed to test a specific range of constant incubating temperatures.

The first experiment during the 1952-53 season was designed to test high temperatures. In addition, one lot of eggs was subjected to a very low constant temperature in order to establish a base for future trials.

The 1953-54 experiment tested the low range of temperatures. Eggs from two races of chinook salmon were utilized to determine whether any differences in tolerance to low temperatures existed.

MEAN MORTALITIES FOR CHINOOK SALMON EGGS INCUBATED AT CONSTANT WATER TEMPERATURES

Year	Source		Desired incubation temperatures - ° F. 35.0°	37.5°	40.0°	42.5°	45.0°	47.5°
1952-53	Entiat	Actual water temperature	34.56°	------	------	------	------	------
		Percentage of mortality	100.0	------	------	------	------	------
1953-54	Skagit	Actual water temperature	34.89°	37.29°	40.04°	42.54°	44.87°	------
		Percentage of mortality	98.7	30.9	10.2	2.1	0.9	------
1953-54	Entiat	Actual water temperature	35.10°	37.35°	40.05°	42.63°	------	------
		Percentage of mortality	99.6	52.6	18.5	6.0	------	------
1955-56	Entiat	Actual water temperature	------	------	39.94°	42.40°	44.67°	47.38°
		Percentage of mortality	------	------	2.7	1.3	0.7	0.6

			50.0°	55.0°	57.5°	60.0°	Least difference for significance[1]
1952-53	Entiat	Actual water temperature	49.75°	54.88°	57.53°	59.53°	
		Percentage of mortality	7.1	5.7	6.1	12.4	1.99
1953-54	Skagit	Actual water temperature	------	------	------	------	
		Percentage of mortality	------	------	------	------	5.80
1953-54	Entiat	Actual water temperature	------	------	------	------	
		Percentage of mortality	------	------	------	------	7.61
1955-56	Entiat	Actual water temperature	49.23°	------	------	------	
		Percentage of mortality	1.1	------	------	------	1.04

[1] Least difference at the 5% confidence level.

The third experiment, during 1955-56, was designed to duplicate the middle range of temperatures tested in the two previous trials and to fill in the temperature gap that existed between the two. The results of this experiment would either confirm or invalidate previous results.

Results of Experiments

The results from each of the three experiments designed to test the effect of constant incubating temperatures on the development of chinook salmon eggs will be considered separately.

Mean egg mortalities and incubating temperatures for the three experiments are presented in the table.

During the 1952-53 season eggs from the Entiat River chinook salmon stock were incubated at constant temperatures of 35°, 50°, 55°, 57.5°, and 60° F. Complete mortality occurred in the lot of eggs incubated at 35°, which established this temperature as the lower limit for future experiments. Mortalities were similar among lots of eggs incubated at 57.5° and lower; however, a significant increase in the mortality occurred at 60° F. The upper threshold temperature was therefore established at between 57.5° and 60° F.

Low incubation temperatures were tested during the 1953-54 experiment. Two races of chinook salmon eggs (Skagit River and Entiat River) were subjected to constant temperatures of 35°, 37.5°, 40°, 42.5°, and 45° F. Virtually complete mortality occurred in the lots at 35° F., as had been noted in the 1952-53 experiment. Mortalities in the lots incubated at

37.5° and 40° were significantly higher than in those lots subjected to temperatures of 42.5° and 45° F.

On the basis of the mortalities which occurred in the various lots, the lower threshold temperature of normal development was established at the level of 40° to 42.5° F. The threshold temperature was apparently the same for both races of chinook salmon. Although the Skagit eggs showed less mortality as a group when compared to the Entiat eggs, the significant difference between losses within both groups occurred between those incubated at 40° and those incubated at 42.5° F.

The 1955-56 experiment duplicated the middle range of temperatures tested in the two previous experiments. Constant incubation temperatures of 40° to 50° F. in intervals of 2.5° were tested. The 47.5° temperature filled the gap between the high and low temperature trials. The results of this experiment confirmed the results of the two previous trials. Though all mortalities were low, a significant difference occurred between the lots incubated at 40° and 42.5° F., reaffirming this range as the lower threshold.

Discussion

The range of incubating temperatures between 42.5° and 57.5° F., established by these experiments as the range for normal development, applies only to constant temperatures. The stage in development of the eggs when they are subjected to temperatures outside this range is apparently a more important factor than temperature alone. Johnson and Brice (1953) found that chinook salmon eggs sustained excessive mortality when the initial incubation temperature was above 60° F., even though within a month the temperature was below 55° F. During the 1954-55 season there was conducted at the Entiat laboratory an experiment in which initial temperatures were within the normal development range and then dropped below this range.

This experiment was designed to duplicate several years' temperature patterns of Sashin Creek, Alaska, to determine whether stream temperatures during the incubation season were responsible for poor survival of pink salmon (O. gorbuscha) in certain years. Five different year patterns were chosen, two good survival years and three poor. Entiat River chinook salmon eggs, as well as pink salmon eggs, were utilized to provide additional information. Incubating temperatures were above 42° F. for a month for all lots of eggs and then were lowered gradually until some lots were subjected to temperatures as low as 33° F. for several weeks. No significant differences in mortality occurred in the pink salmon egg lots, indicating that low temperature alone was not responsible for poor survival. In spite of the period of very low temperatures, the mortality in the chinook salmon eggs did not exceed 2 percent in any lot.

Other investigators have obtained similar results while testing the effect of low temperatures on eggs that were in an advanced stage of development. Fish and Burrows (1939) held eyed chum salmon (O. keta) eggs in iced egg-transportation cases for periods of 2 to 14 days before transferring them to incubating trays, and the eggs subsequently hatched. The incubation period was prolonged somewhat for those eggs held 8 days or longer in the iced cases, but no increase in mortality resulted.

The cause of death due to adverse temperatures is not clear. Johnson and Brice (1953) blamed "coagulated yolk" disease for the high loss of fry and fingerlings from eggs incubated at high temperature. Egg mortality had been relatively high in this lot also. Hayes (1949) suggested that growth and differentiation in organogenesis within the embryo were two essential processes taking place in mutual relationship at optimum temperatures. A deviation too far from the optimum temperature might cause the two processes to become so far out of coordination that death of the embryo would result. Hayes, with Pelluet and Gorham, concluded (1953) that dislocations in the order of differentiation were possible with a change in temperature, that certain of these might

take place within the normal limits for survival, though others might be lethal to the embryo.

Although salmon eggs have been shown to be resistant to low temperatures during certain stages of development, the fact remains that constant incubating temperatures below 42.5° F. result in excessive mortality. The eggs of salmon which spawn in cold headwater streams late in the fall when the water temperatures are falling rapidly apparently have little chance of survival. The constant temperature experiments showed that mortalities at 40° were several times those at 42.5° and reached almost 100 percent at 35° F. In future experiments it is planned to determine at what stage of development chinook salmon eggs can tolerate low temperatures.

Summary

Results of the constant-temperature experiments to determine the threshold temperatures for the normal development of chinook salmon eggs may be summarized as follows:

1. The 1952-53 experiment using high constant incubating temperatures established the range between 57.5° and 60° F. as the upper temperature threshold. Incubation at 35° F. resulted in complete mortality, thereby establishing this temperature as a lower limit for future trials.

2. Low incubation temperatures tested in the 1953-54 experiment established the range between 40° and 42.5° F. as the lower threshold. No difference in tolerance to low temperatures was demonstrated between chinook salmon eggs from Entiat River and Skagit River.

3. The 1955-56 experiment, which utilized temperatures ranging from 40° to 50° F., confirmed the results of the previous experiments. Although mortality was very low in all lots of eggs, there was a significant difference between those incubated at 40° F. and those incubated at higher temperatures.

4. Experiments during the 1954-55 season indicated that pink and chinook salmon eggs could tolerate long periods of very low temperatures if the initial incubation temperature was above 42° F. for a month.

5. The cause of death due to adverse temperatures may be lack of coordination between growth and organic differentiation within the embryo or dislocations in the order of differentiation.

6. Constant incubating temperatures of 40° F. or below resulted in excessive mortalities, with practically total losses at 35°. Salmon eggs deposited at water temperatures of 40° F. or below may be expected to make a less than optimum contribution to subsequent adult populations.

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Nonfeeding brook trout absorbed radioactive cobalt from water through the gills.

HISTOPATHOLOGY OF FISH
V. GILL DISEASE

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POSSIBLY NO SINGLE DISEASE accounts for greater annual mortality than gill disease. Apparently endemic in many hatcheries, the disease is characterized by periodic sharp upsurges which are sometimes correlated with rising water temperatures, excessive foreign matter in the water (Wales and Evins 1937), or borderline nutritional conditions.

Two men have been primarily responsible for the advances in our understanding of gill disease and, ambiguously, for the existent controversy concerning the causative agents. Davis (1926) attributed the disease to a filamentous bacterium and thereby established the basis for the term, "bacterial gill disease." Wolf (1945) produced similar gill lesions on diets deficient in pantothenic acid and introduced the concept, "nutritional gill disease." Both workers were quite emphatic in their identification of the respective causative agents, and this has led to some confusion in current concepts. Davis, however, in a later publication (1953), while still adhering to a rather rigid separation of the two entities, advanced the hypothesis that both conditions could exist in the same fish simultaneously and that, in fact, a deficiency of pantothenic acid might increase the susceptibility of the gills to a bacterial infection.

An adequate comparison of the two lesions has not been made previously. The purpose of this paper is to furnish this comparison, to describe other occasionally observed gill lesions, and to advance Davis' hypothesis by the introduction of recent literature from the mammalian field.

Methods and Materials

The specimens described in this report were received over a 3-year period through the courtesy of Dr. S. F. Snieszko of the Fish and Wildlife Service's Microbiological Laboratory at Kearneysville, West Virginia; Dr. R. R. Rucker, Fish and Wildlife Service, Seattle, Washington; and a number of field workers who sent samples of moribund fish directly to this laboratory. The pantothenic acid deficient material was supplied by Dr. J. E. Halver from nutritional experiments at this laboratory. All material was fixed in Bouin's solution for approximately 24 hours and stored in 70 percent alcohol. The tissues were sectioned by routine paraffin methods and stained with hematoxylin and eosin and Giemsa stains.

Histopathology

Bacterial and Nutritional Gill Disease

Some confusion exists in the terminology used in describing gill structure. In this paper, the gill arch is the bony support for the filaments, which, in turn, bear the smallest subdivisions or lamellae (figure 1).

Both types of gill disease have been described previously as a hyperplasia of

the gill epithelium with a consequent fusion of the lamellae ("clubbing") and, in extreme cases, of adjoining filaments. Little effort has been made to differentiate the two types histologically, though Davis indicated (1953) that the hyperplasia in the nutritional type was usually not so extensive.

In this study, several histological differences were noted with considerable frequency. The most prominent appeared to involve the original site of the hyperplasia. In the nutritional disease, there was a pronounced tendency for the hyperplasia to initiate on the filament itself, at the very base of the lamellae. The resulting fusion appeared to stem primarily from a proliferation of these basal cells (figure 2). In contrast, the bacterial type of hyperplasia frequently started from the epithelium of the lamellae and was often seen first at the extreme distal tip of the lamellae (figure 3). The position of the fusion on the filament was also characteristic. In the nutritional type, the lesion invariably started at the distal end of the filament and progressed to the proximal portion, usually with rather complete fusion as it moved toward the gill arch (figure 4). The bacterial type also started at the distal end, but this was far less consistent, and frequently small islands of hyperplasia appeared scattered irregularly along the filament (figure 5)--a lesion virtually never seen in the dietary disease.

A very early change in both types was a pronounced swelling of the epithelium on the lamellae. In the nutritional lesion, the lamellae often appeared shortened and the hyperplasia usually engulfed them with very little structural distortion. The lamellae in the bacterial types were usually longer and frequently were bent and twisted into abnormal positions, either with or without subsequent hyperplasia.

Differences in the intensity of hyperplasia were not good criteria of the causative agent. Complete fusion of adjacent filaments was observed in the nutritional type (figure 6), with practically the same incidence as in the bacterial type. Conversely, rather limited hyperplasia was sometimes observed in moribund fish suffering a severe mortality with heavy concentrations of typical myxobacteria.

In the bacterial lesions described here, there was an apparent close relationship between the bacteria and the hyperplastic cells. R. E. Burrows, of the Fish and Wildlife Service's Salmon-Cultural Laboratory at Entiat, Washington, and Rucker (Rucker et al. 1952) described a "plaque" as a developmental feature in bacterial gill disease. Apparently similar structures were frequently observed in our material. These consisted of single, globose cells projecting from the lamellae. These cells were often filled with intensely basophilic granules that did not resemble myxobacteria (figures 7 and 8). As the hyperplasia developed, these cells either disappeared or were obscured by other cell types. At this point, there was an apparent increase in the typical filamentous bacterial forms much as described by Burrows and Rucker.

There was also evidence, however, that bacterial gill disease may not be an uncomplicated lesion of the gills. Rucker, Earp, and Ordal (1954) noted that myxobacteria of certain types were quite invasive and on occasion could be recovered from the internal organs. In the material described here, filamentous bacteria were never observed in the internal organs of fish with typical gill lesions. However, in almost every instance, lesions were observed in the hemapoietic tissue of the kidney, resulting in necrosis of small numbers of endothelial cells. Frequently, inclusionlike particles (figure 9) were observed in these cells, similar to those described in the myxobacterial infection termed "cold-water" disease (Wood and Yasutake 1956). In the early gill lesions, plaque cells and swelling of the lamellae were often observed without the concurrent presence of bacteria. There was at least a suggestion that these lesions were correlated with the kidney damage and the inclusion particles in the kidney cells.

Fish (1935) described two types of bacteria from gill lesions which did not resemble the typical filamentous myxobacteria. We also observed different bacterial types in high concentrations which

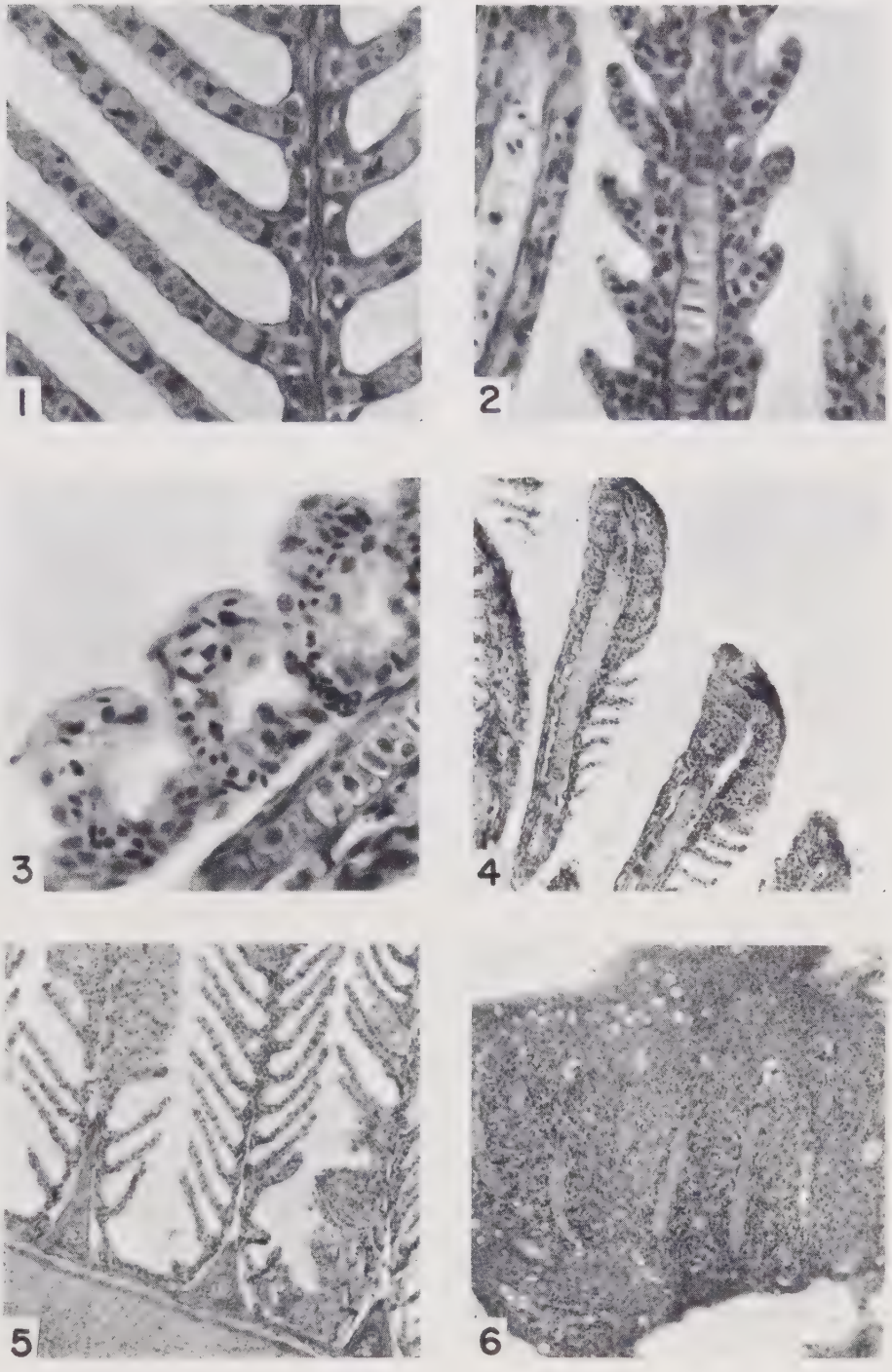


FIGURE:

1.--A normal gill filament and its lamellae. x 400.

2.--Early changes in a pantothenic acid deficient gill lesion. Note the shortened, swollen lamellae and the basal hyperplasia. x 400.

3.--Early changes in a bacterial gill lesion. Note the hyperplasia on the lamellae. x 400.

4.--The distribution of the nutritional lesion on the distal portion of the filament. x 100.

5.--The scattered distribution of the bacterial lesion. The gill arch is at the lower left. x 100.

6.--Complete fusion of adjacent filaments in the nutritional lesion. The rodlike structures are the cartilage cells which support the filaments. x 100.

were considered, by association, as the causative agent of similar gill lesions. These forms differed morphologically by being short rods. Unfortunately, material was not available for bacteriological culturing. In one instance with wild fish, the forms were present in an apparently pure state (figure 10); whereas, in another instance, hatchery brook trout had a mixed infection that consisted of both short rods

FIGURE:

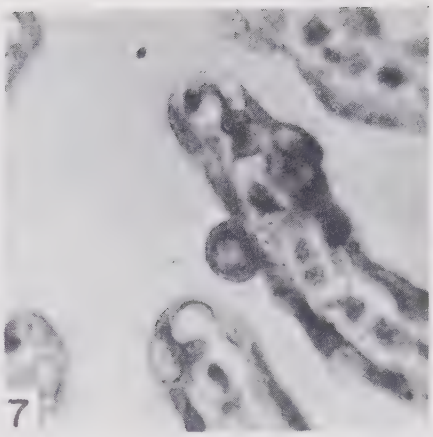
7, 8.--Early bacterial lesions showing the "plaque" cells. x 900.

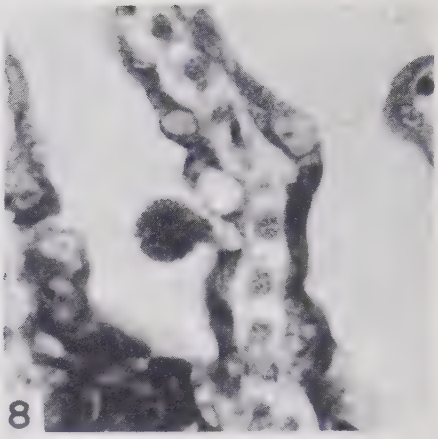
9.--Inclusions in kidney cells. x 900.

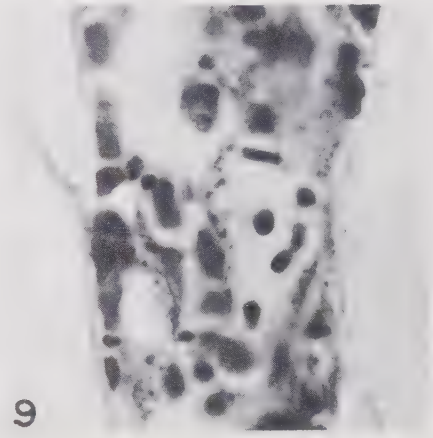
10.--A bacterial lesion associated with short, rod-shaped organisms. x 900.

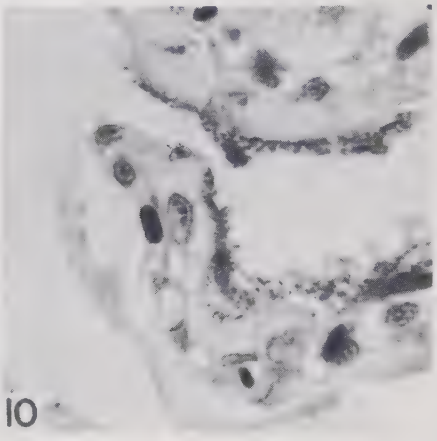
11.--A mixed bacterial infection. The myxobacteria are on top of the solid mass of rod-shaped bacteria. x 900.

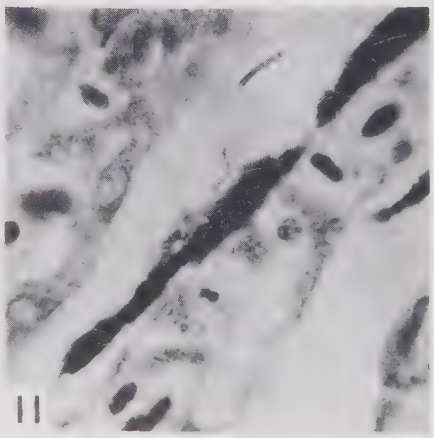
12.--Typical myxobacterial organisms. x 900.

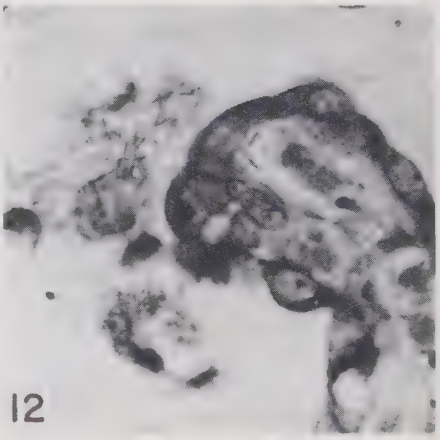












and the long filamentous forms (figure 11). As described previously (Wood and Yasutake 1956, myxobacteria were found in the gills in "cold water" disease, as were short, gram-negative rods in "red mouth" disease--and it may be presumed that organisms would appear in any other similar bacterial septicemia. In these instances, however, the organisms were found inside the capillaries of the lamellae and not on the surface epithelium, as are the typical myxobacteria (figure 12).

Other Gill Lesions

Dr. Snieszko has observed, in several eastern hatcheries, gill lesions which were characterized grossly by apparent minute hemorrhages in the gill filaments. "Hemorrhagic gill disease" is the term

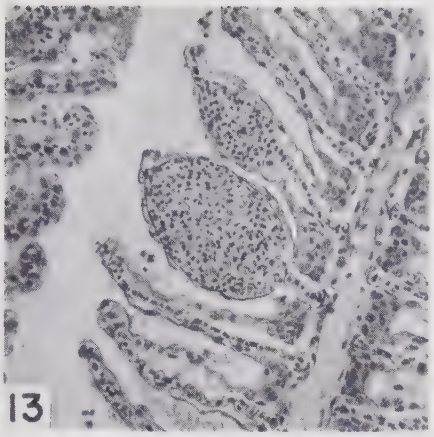
FIGURE:

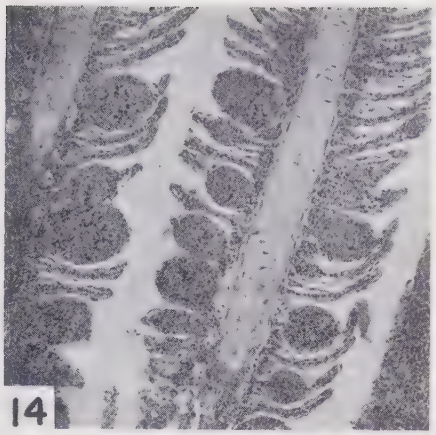
13.--"Hemorrhagic" gill disease. One lamella is in an advanced stage; the other, in a relatively early stage. x 200.

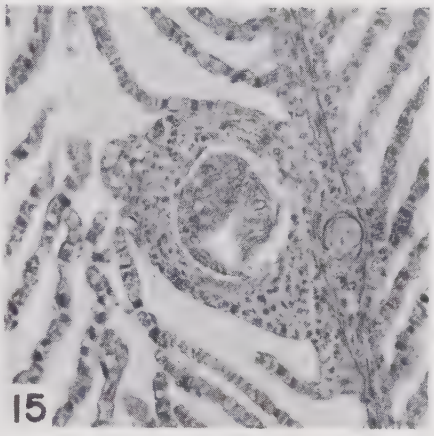
14.--Severe "hemorrhagic" gill disease. x 100.

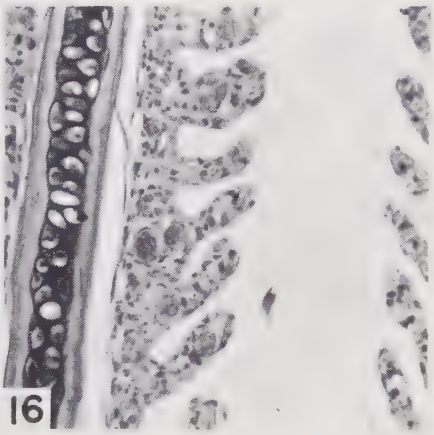
15.--Hyperplasia around an unidentified parasite, probably metacercaria of Nanophyetus salmincola. x 200.

16.--Hyperplasia associated with an unidentified parasite, possibly a microsporidian. x 200.









that Dr. Snieszko has used for this condition (private communication). Considered histologically, these gills showed pathology distinct from that of either the bacterial or the nutritional type. During the early stages of development, the capillaries of individual lamellae suddenly expanded into globose masses of blood (figure 13) which gave the gill its characteristic gross appearance. The lesions were not true hemorrhages, as the blood appeared to remain in circulation. In one case, the lesions were associated with filamentous bacteria and an unknown toxic substance in the water. In this instance, the disease progressed histologically to the typical bacterial lesion. In another case, however, bacteria were not present and the gill contained multiple small globose blood masses (figure 14). The etiology of these lesions remains obscure.

The occurrence of marked gill hyperplasia was occasionally observed in conjunction with heavy parasitism of various types. Usually there appeared to be a direct relationship between the parasites and the resulting hyperplasia (figures 15 and 16). Sometimes, however, there were dual infections, with various types of bacteria apparently contributing to the hyperplasia. This leads to the important--and as yet unanswered--question of the role of the parasite in introducing the bacterial organism.

Discussion and Summary

Histologically, there are some identifying characteristics which can be used to distinguish bacterial from nutritional gill disease. It appears, however, that the simultaneous occurrence of both types may frequently complicate the diagnostic

picture. In routine diagnostic material, we have observed typical lesions of both types and intermediate forms, which suggest that both nutritional and infectious agents are operative simultaneously.

A major gap in our knowledge of gill disease could be closed by better understanding of the effect of borderline nutritional conditions on the development of the bacterial lesions. Investigators' attempts to produce bacterial gill disease experimentally have not been successful, though the lesions of nutritional gill disease have been reproduced with comparative ease. To date, however, no experimental work has combined these two approaches by attempting to induce a bacterial infection in fish deficient in pantothenic acid. In this connection, recent work in the mammalian field may be highly significant. Zucker and Zucker (1954) described a respiratory infection which was closely correlated with a deficiency of pantothenic acid in the rat. These lesions were caused by a corynebacterium which normally was not pathogenic. On deficient diets, however, the animals apparently lost their resistance to the organism. These observations were by no means confined to a single laboratory, and the occurrence of the phenomenon was amply confirmed by other workers. This offers an attractive analogy to conditions frequently observed with fish.

There has been considerable controversy over the initiating factor of the hyperplasia, with Wolf postulating that a chemical irritant was a necessary adjunct to a pantothenic acid deficiency, and Davis contending that the bacteria themselves supplied the necessary irritant.

This study supplies few data in support of or in opposition to Wolf's hypothesis. The nutritional experiments were conducted in small troughs with small numbers of fish; overcrowding, with subsequent accumulation of metabolic products, which might act as a chemical irritant, was not encountered. No effort was made, however, to determine whether the gills of these fish deficient in pantothenic acid would respond to a chemical irritant by increased hyperplasia. In these fish, though some filaments were completely fused, others were apparently unaffected, and there was ample room for hyperplasia to involve additional filaments. Rucker, Johnson, and Kaydas (1952) were unable to produce hyperplasia with ammonium chloride added to the water as an irritant, but these experiments were not conducted with fish deficient in pantothenic acid.

There are strong indications that bacterial gill disease is a symptom of a more complex and generalized infection. The gill lesions may be the immediate cause of death, and prevention of these lesions by external therapy may prevent heavy mortalities and may disrupt the cycle of the organism in an unknown manner. These are questions which obviously require additional investigation.

In an advanced case of bacterial gill disease, Snieszko (private communication) also isolated from kidney tissue bacteria which were gram-negative and motile but definitely were not myxobacteria. Treatment with pyridylmercuric acetate reduced the mortalities, and the kidney organisms could no longer be isolated. This may have been a case in which bacterial gill disease produced conditions allowing invasion of tissues by apparently saprophytic bacteria.

Bacteria other than the typical filamentous myxobacteria are associated with gill lesions. Parasites also are responsible for hyperplasia when present in large numbers and may be the vector for the introduction of bacterial infections.

An additional lesion termed "hemorrhagic gill disease" is of unknown etiology.

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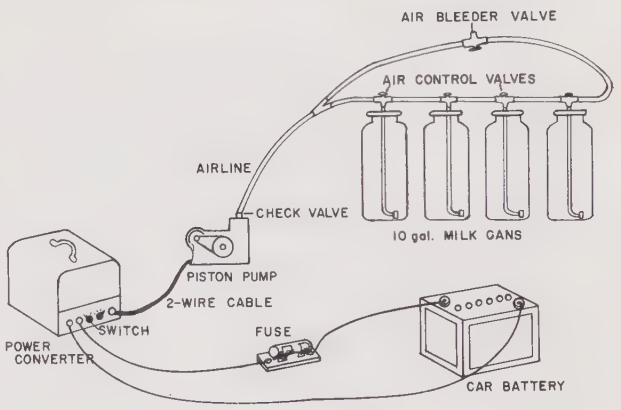
SIMPLIFIED TRANSPORT FOR SMALLER NUMBERS OF SALMONIDS

Specially designed, refrigerated fish tanks that are equipped with gasoline-powered aerators, transported on trucks or trailers, are generally used when it is desired to move fish over long distances. Occasionally, however, fishery biologists find it necessary to transport relatively small lots (100 to 10,000) of salmon or trout fingerlings for use in experimental work. In such situations, the large containers and elaborate equipment represent undesirable expenditures.

K. G. Weber, fishery biologist working with the Pacific Salmon Investigations Unit of the U. S. Fish and Wildlife Service, has devised an economical means of transporting limited numbers of live fish. Readily adaptable to use in passenger automobiles, this method eliminates the need for special equipment or operating personnel.

To provide a source of alternating current, a vibrator converter has been connected directly to the car battery (see figure). The converter furnishes power to operate an aerator of the aquarium type. Through a rubber-tubing manifold system, the aerator supplies air to four 10-gallon milk cans that hold the fish. Chunks of ice are used in the cans to keep down the temperature of the water.



(Drawing courtesy of Mr. Weber)

"On two different occasions," writes Mr. Weber from headquarters in Seattle, Washington, "though outside air temperatures were above 90° F., cans of fingerling salmon (both coho and blueback) were transported safely more than 300 miles. The salmon were in these cans 8 hours. Mortality was negligible.

"With tank containers instead of the milk cans, but using similar aerating and cooling techniques, adult salmon or trout may also be transported safely."

Cost of this equipment--aerator pump (240 cubic inch/minute) and vibrator converter--was less than $40.

BLUE-SAC DISEASE INVESTIGATIONS:
MICROBIOLOGY AND LABORATORY INDUCTION

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THE FIRST REPORT OF THIS WRITER'S BLUE-SAC DISEASE INVESTIGATIONS was made 2 years ago (Wolf 1954). The purpose of this, the second report, is to present what are believed to be the most important of the recent results.

Microbiological Findings

Blue-sac disease has been attributed to different causes by different authors. Standard references on fish diseases have included infection as one possible cause. Von Betegh (1912) was the first to presume bacteria to be the responsible agent. Later, Guberlet, Samson, and Brown (1931) reported varying degrees of success in transmitting blue-sac disease by exposing fry to cultures of bacteria which were identified as similar, if not identical, to those described by von Betegh. The results of other workers are just as convincing that blue-sac disease is not infectious. Dieterich (1939), whose work is the best published reference on the subject, did not find the condition to be infectious.

The writer investigated the bacteriology of blue-sac disease and employed a variety of techniques. Microscopic examinations of blue-sac fluid seldom showed bacteria. Culture of the fluid, aerobically and anaerobically, on several bacteriological media showed that bacteria were never present in all diseased fry; more commonly they were found in less than half of the fry examined by culturing. Most of the bacteria that were found were fluorescent pseudomonads--common aquatic saprophytes. Evidence from this study also showed that most of the bacteria found in blue-sac fry were opportunists and contaminants; they were probably secondary to the disease itself.

Eggs and sac fry were held for extended periods of time--even weeks--in the presence of living blue-sac fry, crushed blue-sac fry, or blue-sac fluid. It seemed reasonable to assume that if the disease was infectious, this type of treatment would present an opportunity for the disease to spread. The results, however, did not show infection.

Bacteria are but one kind of infectious agent. Viruses cause some diseases, and logically the presence of a virus could be suspected in an infectious disease where bacteria or other organisms were not involved. These organisms cannot be cultivated on bacteriological media, but they can proliferate in living cells. Using methods of tissue culture, this investigator added filtered blue-sac fluid to cultures of subadult trout swim-bladder and gonad tissue. The work revealed no evidence that there were viruses associated with blue-sac disease.

This paper is based on work incorporated in a Ph.D. dissertation at Utah State Agricultural College, Logan, Utah.

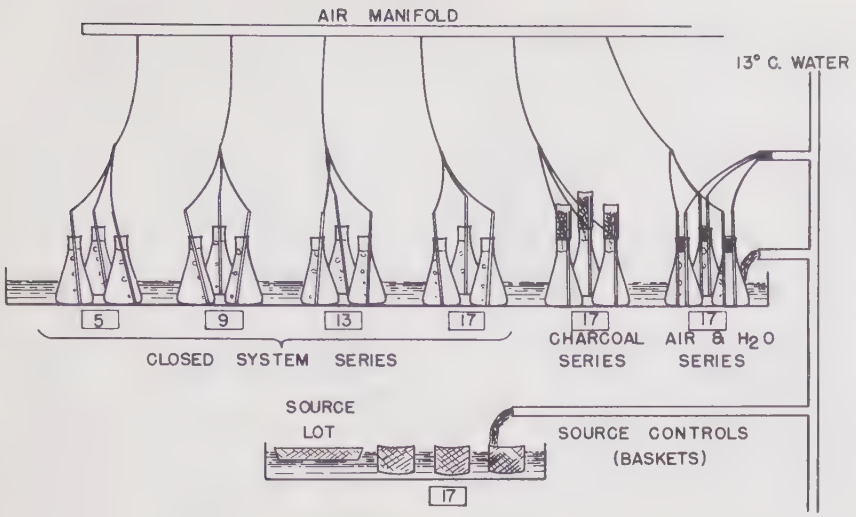

FIGURE 1.--The experimental setup as prepared for the closed-system induction of blue-sac disease. The numbers within the rectangles represent the number of days that the series were initiated before hatching occurred.

Laboratory Induction of Blue-Sac Disease

When eggs and sac fry were kept in aerated flasks for weeks in order to expose them to such agents as bacteria or blue-sac fluid, they commonly became sick with blue-sac disease. It was soon evident that the disease was independent of the agents used but was related to the time the eggs and fry had been held in a closed system. This led to development of the methods whereby it became possible routinely to induce blue-sac disease in the laboratory. Results were consistent when eggs were used; in general, more blue-sac disease appeared when younger eggs were used.

In one experiment which was designed to test the idea that the cause was present in closed-system incubation, eggs were distributed among 4 series of half-liter flasks at intervals of 4 days (figure 1). These flasks received only air, but a control series received both air and water. An additional control consisted of small baskets held in a trough of flowing water. All eggs were kept at 13° C. Another series of flasks received only air, but the air was made to recirculate the water over a bed of activated charcoal.

High percentages of blue-sac disease occurred among the fry in those flasks which had received only air (figure 2). An exception was the oldest closed-system series, in which all the eggs died before hatching; in contrast, the eggs in both control series and in the charcoal-filter series which had been started on the same day had a hatch of more than 90 percent. Products excreted by developing eggs and fry accumulated in the closed-system flasks. Ammonia was one of the materials, and measurements showed that more of it accumulated in flasks of the series held the longest than in flasks of the youngest series. More blue-sac fry developed in the flasks which had the greatest concentration of ammonia than in the flasks containing less ammonia. Activated charcoal was changed whenever more than a trace of ammonia was encountered. Although about 40 percent blue-sac fry occurred in the charcoal-filter series, it was far less disease than occurred in the other closed-system flasks which were in operation little more than half as long. The activated charcoal adsorbed metabolic ammonia, and there was a concurrent reduction in the incidence of blue-sac disease.

If products of egg and sac-fry metabolism caused the condition, theoretically it should be possible to produce blue-sac disease by exposing eggs and sac fry to synthetic forms of the same products of metabolism.

Ammonia and urea are two principal products of fish metabolism. Synthetic forms of these compounds were used in an attempt to induce the disease. In this

experiment, eyed eggs from redds were distributed among straight-walled glasses. The eggs rested on platforms of plastic screen well above the bottom. Water-inflow lines discharged below the eggs so that movement was always upward. Some of the glasses received hatchery water from a stainless-steel reservoir. Other glasses received hatchery water to which ammonia and urea were added. Two p.p.m. of each were used at first, but the concentration was gradually increased until 12 p.p.m. of each were added on the 7th day, and this concentration was maintained until the end of the experiment. The last portion of eggs was distributed among small baskets which floated on the surface of the untreated water. Reservoirs were filled twice a day, and water temperature around all eggs was about 13° C.

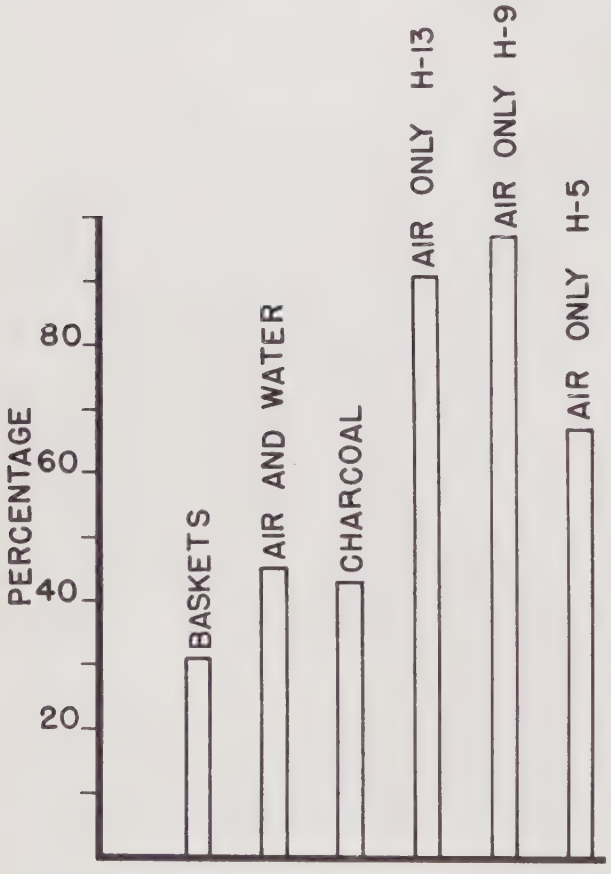

FIGURE 2.--Average maximum incidence of blue-sac disease among the fry that were hatched and held in closed systems.

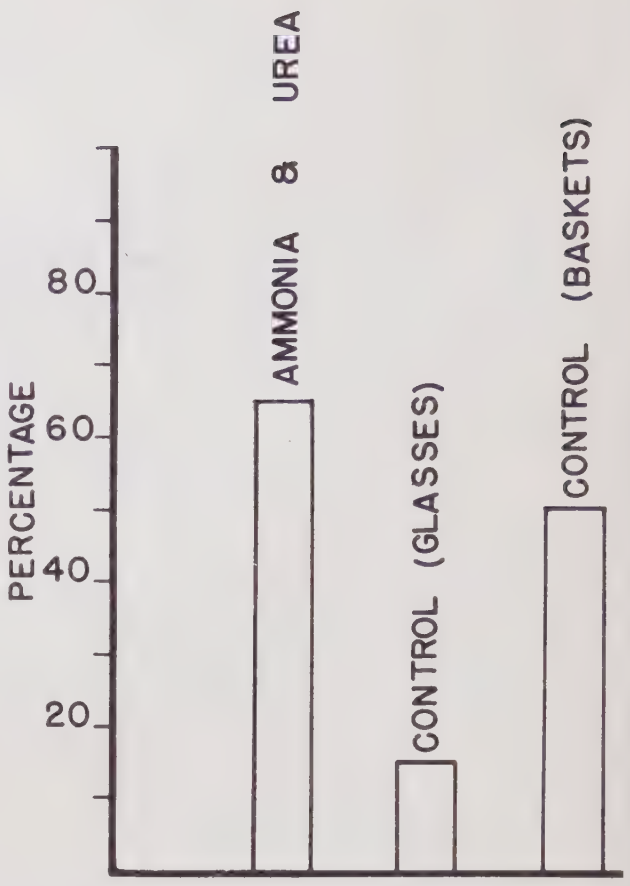

FIGURE 3.--Average maximum incidence of blue-sac disease under experimental exposure to ammonium hydroxide and urea.

More than 60 percent blue-sac disease occurred among fry in the chemically treated water, but only 15 percent blue-sac disease occurred among fry in the glasses that received only hatchery water (figure 3). Half of the fry in the baskets developed blue-sac disease. As the baskets remained motionless on the surface, the explanation that seemed to fit the results best was that stagnation occurred around the eggs. A dye added to the reservoir confirmed this and showed that currents in the tank were effectively confined to the bottom where the siphon intakes were located.

Significance of the Results

Exophthalmos in fish (popeye) is a symptom which can result from any of

several causes. It is possible that blue-sac disease is just a general symptom of an abnormal condition among sac fry. The principal reason for making this statement is confidence in Dieterich's work (1939). She attributed blue-sac disease to hybridization, to overfeeding the parents, and to stripping fish that were too young. Considering today's methods of trout culture wherein species are maintained separately and are fed proved levels of scientifically developed diets, however, it is difficult to conceive of blue-sac disease as being a result of these factors. Because blue-sac disease occurs both in the wild and in the hatchery among fry from wild populations, there is added difficulty in trying to reconcile the disease with parental nutrition or age. Most of the results of this writer's investigation agree with those of Dieterich; therefore, there is respect for her work, and reason dictates that her conclusions should not be ignored. It is considered equally possible, however, that the effect of metabolic wastes causes all blue-sac disease. The idea that the effect of metabolic wastes may cause blue-sac disease is consistent with present knowledge of the condition. This idea offers an explanation for and correlates the following facts:

1. Usually not all the fry on a tray or in a basket are affected.
2. Among well-mixed lots of eggs, the disease occurs in some trays or baskets of a trough but not in others.
3. Attempts to cure the condition with chemical treatment have been ineffective.
4. No one has consistently induced the disease.
5. No one has consistently demonstrated infection.
6. Shipped eggs so often yield blue-sac fry.
7. The cause of the disease has been disputed, and many hypotheses have been presented.
8. Histologically the disease is typified by severe kidney and circulatory system damage.

These facts, until now, have seemed unrelated; no single postulate can account for them so well as the hypothesis that the cause is a result of metabolic wastes.

Certain types of cancer can be produced experimentally in the laboratory, but the basic cause of cancer has not been demonstrated. A similar situation exists in the study of blue-sac disease. It has been produced experimentally, but the cause has not yet been demonstrated to exist in the hatchery or in the wild. There is, however, much circumstantial evidence for its existence. Small-mesh screen trays, especially in the Clark-Williams method of incubation, often trap gases escaping from solution in the water and allow huge bubbles to form. These bubbles may occupy most of the area between trays of eggs and interfere with the normal flow and direction of water. Trays which are too small for the trough permit water to bypass a stack easily. Overcrowding in any method of hatching interferes with the proper washing action of water. Fungus or debris can blanket eggs. These are all mechanical factors that interfere with movement of water past the eggs. Burrows and Chenoweth (1955) found dead areas in the water of several types of rearing ponds. This writer believes that similar conditions exist in hatching troughs and, if anything, are more numerous, more severe, but proportionally smaller. (These factors will necessitate pinpoint sampling in order to demonstrate toxic levels of wastes.)

Fish-culturists have long recognized that blue-sac disease is more common among shipped eggs. This was probably what led to the suggestion that pressure, drying, or jarring of the eggs caused the disease. Attempts to demonstrate that the disease was caused by pressure, drying, or jarring usually resulted in killing the eggs if the treatment was severe, but never induced blue-sac disease. Although low temperatures retard their rate, eggs continue to develop during shipment and to excrete the products of metabolism. If the wastes are not removed, they may literally envelop the eggs in a concentrated film of pollution. The kidney may be pumping its products against an increasing osmotic pressure. If it is severe enough, death

results; intermediate severity results in damage--blue-sac disease. This writer believes that the primary function of ice in egg shipments is to serve as a source of water; secondarily, it cools the eggs. If eggs are poorly iced, insulation may maintain a favorable temperature, but there will be an inadequate flow of water.

In theory, ideal egg incubation can be achieved in a system which supplies a positive flow of water in alternate directions. Laboratory pipette washers employ this principle. Water enters and fills a vertical column from the bottom; when capacity is reached, a valve opens and the water drains. Pipette washers could be readily adapted to salmonid egg incubation, or alternate-flow incubators could be fabricated. In either event, a number of shallow, rigid screen trays could be stacked in a carrier within the column. Based on its dimensions (6 by 19 inches), a commercial pipette washer could hold trays that contained between 55,000 and 60,000 eggs (250 to 275 eggs per ounce). This washer occupies less than 1 square foot of floor space; its water consumption would be economical, and in no other way is the washing action of water so easily guaranteed. As with the drip incubators, the last few days of incubation would have to take place within a trough.

Recommendations

Successful control of blue-sac disease lies in its prevention. On the basis of present knowledge, the following recommendations should be of value:

1. Maintain a high standard of cleanliness. Debris and filth not only obstruct water flow but, in decomposing, can contribute products similar to the metabolic wastes of fish.

2. Proper egg disinfection and subsequent treatments with malachite green reduce egg losses and inhibit the growth of Saprolegnia. The blanketing effect of fungus may be significant in obstructing water flow.

3. Do not overload trays or baskets. Ideally, there should be space between all eggs.

4. Where a choice exists, inclined hatching trays (Davis 1953: 37, figure 10a) with long-mesh screen offer least resistance to water flow. Unless trays are fitted tightly in the trough and kept clean, the Clark-Williams method of egg incubation offers greatest probabilities of presenting conditions favorable for generating blue-sac disease.

5. Persons responsible for egg shipments should not overload the trays (trays are preferred to bulk shipment) and should allow as much room as possible for ice.

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A CHEMICAL COMPARISON OF HATCHERY AND WILD BROOK TROUT

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PREVIOUS EXPERIMENTS AT THE CORTLAND LABORATORY (Phillips et al. 1954) have shown that hatchery foods are nutritionally superior (in the chemical constituents analyzed) to the natural food of brook trout. In general, superior foods produce a superior product; therefore, a chemical comparison of hatchery and wild brook trout should provide a measure of the production efficiency of the two types of food. Through the cooperation of field workers during the summer and fall of 1955, a number of samples of wild brook trout, from widely separated areas of the United States and Canada, have been received and compared with hatchery-reared trout on the basis of chemical composition.

Method

The wild brook trout were preserved in either 5 percent formalin or 95 percent ethyl alcohol. After they had been dried in a vacuum oven to determine water content, the samples were analyzed for protein, ash, fat, and the iodine number of the fat.[1/] The average weight of the wild trout was 14.1 grams (the range, from 2.1 to 26.3 grams); the average weight of the hatchery trout was 11.6 grams (the range, from 3.9 to 18.8 grams). Twenty-one samples of wild trout and 27 samples of hatchery brook trout were available for the comparisons.

The analytical data for hatchery trout represented several years' accumulation of analyses of brook trout fed a variety of diets at the Cortland Station.

Differences between the two groups of trout were measured by Fisher's "t" test for comparing two series of unequal numbers in which pairing of the observations was impossible. The probable error of each of the means was estimated by standard equations.

The data have been summarized in the table and chart.

Chemical Comparison of Experimental Trout

Water. -- Wild trout contained significantly less water in their bodies than hatchery trout. The water content of wild trout ranged from 62.0 to 79.0 percent; that of hatchery trout, from 71.0 to 82.0 percent.

Protein. -- The average protein content of wild trout (21.2 percent) was significantly higher than that of hatchery trout (13.7 percent). The range for wild trout was from 16.0 to 25.3 percent and for hatchery trout, from 10.1 to 15.2 percent.

Ash. --The average percentage of ash in the bodies of wild trout was higher (3.3 percent) than that of hatchery trout (2.0 percent). The results of analyses ranged

[1/] Analytical methods: Protein, micro-Hengar; Ash, ignition to constant weight (muffle furnace); Fat, continuous ether extraction; Iodine number of the fat, Hanus.

from 2.3 to 5.4 percent for wild and from 1.7 to 2.4 for hatchery trout.

Fat.--There was significantly less fat in the bodies of wild trout (average, 3.4 percent) than in the bodies of hatchery trout (average, 5.5 percent). The results of the analyses ranged from 1.2 to 6.3 percent for wild trout and from 3.1 to 7.3 percent for hatchery trout.

THE AVERAGE CHEMICAL COMPOSITION OF NATURAL FOOD, HATCHERY FOOD, WILD TROUT, AND HATCHERY TROUT

	Average--					
		Percentage of--				Iodine number of body fat
	Weight (Grams)	Water	Protein	Ash	Fat	
Natural food----	-----	82.2	11.5	1.7	2.2	125
Hatchery food---	-----	41.4	28.5	6.3	3.2	89
Wild trout------	14.1	71.5	21.2	3.3	3.4	135
P. E. mean----	-----	±0.73	±0.48	±0.11	±0.22	±2.23
Hatchery trout--	11.6	77.2	13.7	2.0	5.5	100
P. E. mean----	-----	±0.30	±0.14	±0.03	±0.14	±0.97

Iodine number of the fat.--The average iodine number of the body fat of wild trout was higher (135) than that of hatchery trout (100). The values for wild trout ranged from 111 to 171, and the values for the hatchery trout ranged from 89 to 111.

Probable error of the means.--All of the means that have been listed in the table are good estimates of the averages, as proved by the probable error of the means.

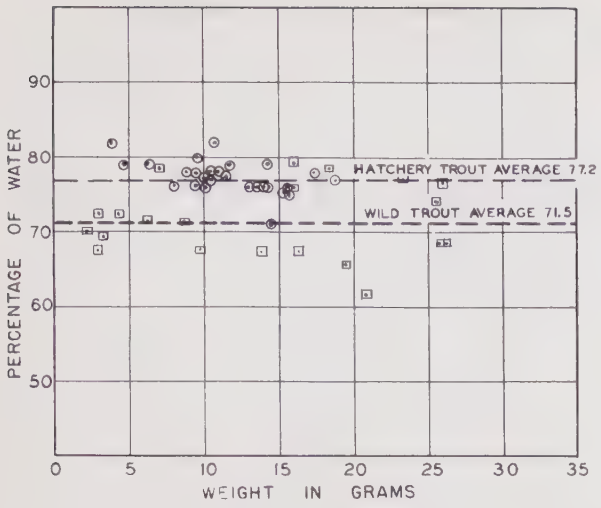
Effect of trout size.--As the groups of wild and hatchery trout were similar in size range (their weights ranging from 2.1 to 26.3 grams for wild trout and from 3.9 to 18.8 grams for hatchery trout), the differences found in chemical composition between the two groups were not considered a function of the size of the trout. Within each group there was no correlation between the size of the trout and the chemical content of the body for water, protein, ash, or the iodine number of the fat. The plotting of the data (see chart) indicated that there was an increase in body fat as the hatchery trout became larger. This correlation did not exist in wild trout.

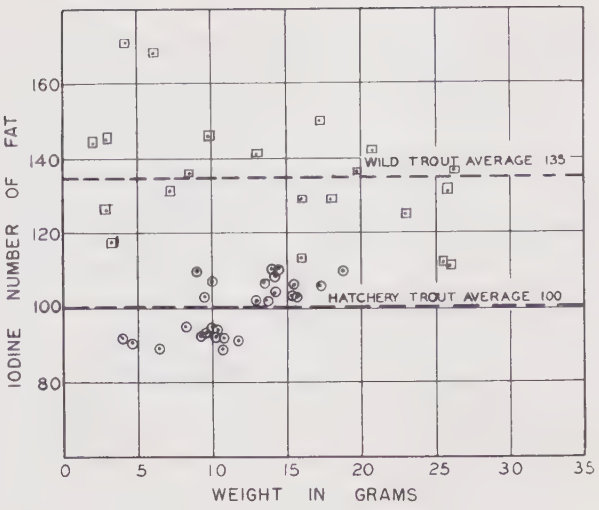
These conclusions apply to trout of the size range used in these experiments. It is possible that a greater range in trout size would show correlations between trout size and the chemical content of the bodies of both groups.

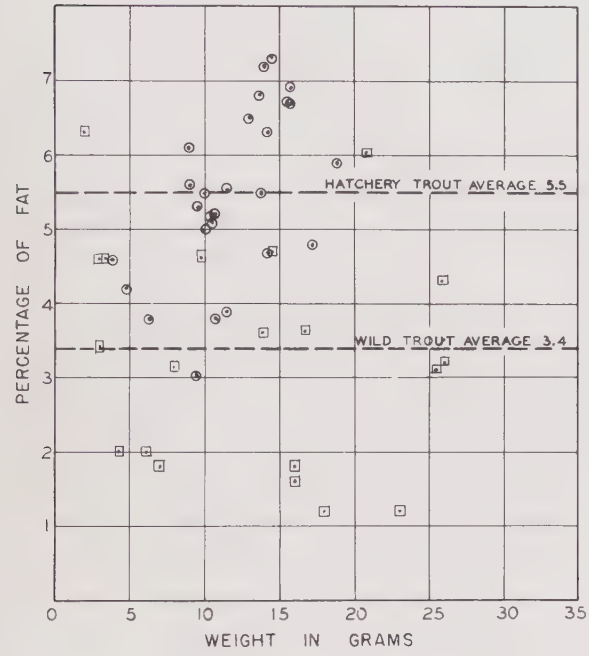
Discussion

On the basis of these analyses, wild trout are considered chemically superior to hatchery trout. The protein and ash contents are higher in wild trout, indicating the production of a greater amount of true fish flesh from natural foods than from hatchery foods. The fat and water contents of hatchery trout are higher than those of wild trout. Neither fat nor water represents the production of true fish flesh. In hatchery trout, the relatively low level of protein and the high level of fat suggest that some of the dietary protein is metabolized to body fat and is not utilized for the primary purpose of protein within the body, i.e., flesh production. The body fat of wild trout is more unsaturated than that of hatchery trout (iodine number of the fat). These differences are correlated with the iodine number of the fats of the two types of food. The hydrogenation of unsaturated fats of goldfish diets lowers the resistance of the fish to both high and low water temperatures (Hoar and Cottle 1952). It is not known whether the relatively saturated fats in the bodies of hatchery trout will have a similar effect on their resistance to extremes of water temperature.

The range of the analytical results, as expressed in percentage, is greater in wild trout than in hatchery trout (see chart). The water content of the body



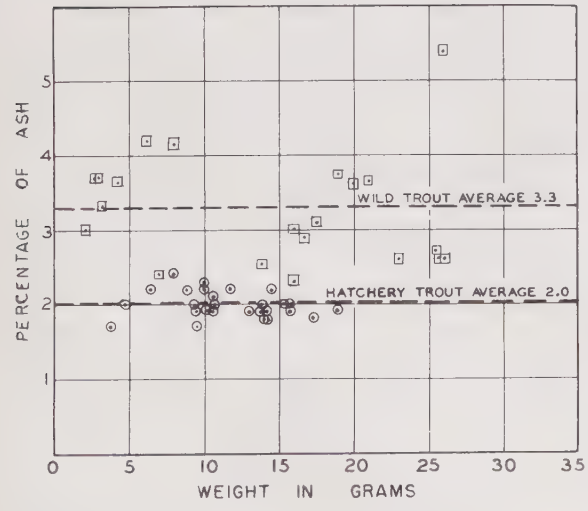


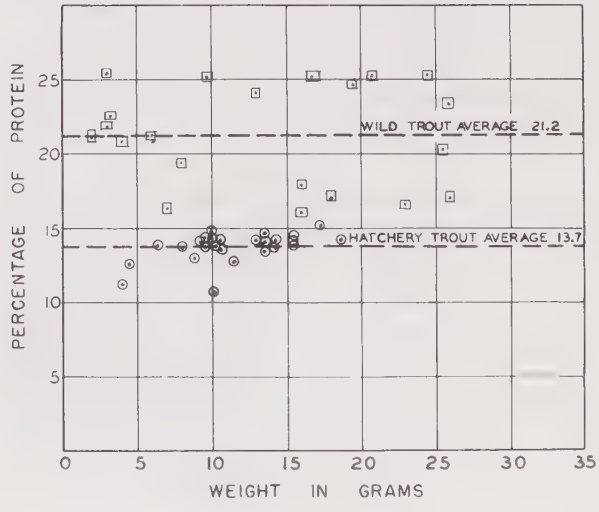


SUMMARY OF THE CHEMICAL COMPOSITION OF HATCHERY AND WILD BROOK TROUT

LEGEND

⊡ WILD TROUT
⊙ HATCHERY TROUT





has a range difference of 17 in wild trout and of 11 in hatchery trout; the protein, 9.3 in wild trout and 5.1 in hatchery trout; the ash, 3.1 in wild trout and 0.7 in hatchery trout; and the iodine number of the fat, 60 in wild trout and 22 in hatchery trout. The range difference in fat content is 5.1 for wild trout and 4.2 for hatchery trout. A variety of feeding habits is expected among wild trout, as the food consumed depends on the organisms present in the environments. In hatcheries, the food is somewhat standardized; though there is a difference in diet mixtures, the variation in chemical composition that is noted in natural foods does not occur in most of the hatchery diets. The range of chemical composition of the wild trout doubtless reflects a difference in foods available to the various samples of wild trout from the environments represented in these studies. When data on the chemistry of hatchery and wild trout are plotted, the data for the hatchery trout are less widely spread (see chart).

Because the number of samples of wild trout is small, any conclusions must be restricted to a comparison of these analyses, and generalizations cannot be made. However, the samples of wild trout are from widely separated areas and reflect a variety of conditions, as evidenced by the greater probable errors of the wild trout samples. Even though the probable errors of the averages are two to three times greater for all analytical categories of wild trout, the comparison of these means with those of hatchery trout shows highly significant differences.

Food Sources and Body Chemistry

On the basis of these analyses of the bodies of wild and hatchery trout, interesting speculative comparisons of the effect of food sources on body chemistry may be made. Although Phillips, Nielson, and Brockway (1954) stated that hatchery foods were nutritionally superior (in items tested) to natural foods, it is concluded from these experiments that natural foods do produce trout that are superior, in many chemical respects, to trout reared on hatchery foods.

The table lists the average composition of natural and hatchery foods (Phillips et al. 1954: 155). Hatchery foods contain approximately half the water, twice the protein, five times the ash, and slightly more fat than natural foods. The iodine number of the fat of hatchery foods is less than that of natural food.

In the body of wild trout, natural food, with half the protein content of hatchery food, produces a higher level of body protein; with one-fifth the ash, produces a greater level of body ash; and with twice the water content, produces a significantly lower level of body water. The fat content of hatchery trout is higher than is justified by the difference in fat content of the two types of food. The higher level of body fat in hatchery trout suggests the utilization of some of the food protein for the formation of fat (since the two food fats are within close range). This conclusion is substantiated in part by the poor utilization of starches by trout (Phillips et al. 1948), a condition that partly eliminates the starches of hatchery diets as a major contributing factor in the formation of fat. The possible formation of fat from protein in hatchery diets indicates a less efficient utilization of hatchery food, than of natural food, for production of flesh.

The conversion of foods into fish flesh is the best measure of the efficiency of food utilization. A conversion of 3 to 4 pounds of hatchery food to 1 pound of trout produced is considered satisfactory in trout hatchery management (Deuel et al. 1952). Proper feeding methods and diets duplicate these conversions under a variety of hatchery conditions. The literature reveals inconsistent results for the conversion of natural foods into fish flesh. Rearing trout on the crustacean Gammarus, Surber (1935) reported a conversion of 6.6; Pentelow (1939), a conversion of 5.0; and Schaeperclaus (1933), a conversion of 3.9. Feeding Chironomus (midge) to trout, Schaeperclaus (1933) found a conversion of 4.4. Cornelius (1933) reported a conversion of 2.3 when feeding trout (cannibalism). Experiments

(unpublished) at the Cortland Laboratory resulted in a conversion of 7.1 when trout were fed maggots of the housefly and a conversion of 2.7 when brook trout were reared on brine shrimp. In experiments in which high conversions are reported, underfeeding is evident in the experimental design. Because of the lack of agreement in the published experimental results, it cannot be concluded that natural foods are less efficient than hatchery foods in the pounds of food required to produce 1 pound of trout.

Since the measure of true growth is the production of fish flesh, the efficiencies of hatchery and natural foods may be compared by establishing a protein conversion for each. This may be accomplished by converting the pounds of food necessary to produce 1 pound of trout to terms of food and body protein.

Experiments and experience over a number of years have established a total conversion of between 3.0 and 4.0 as fair value for the usual type of hatchery foods (Deuel et al. 1952). Using a value of 3.0, the calculations for hatchery diets are:

100 pounds of food provide 28.5 pounds of protein (percentage of protein in the hatchery diet);
100 pounds of food produce 33.3 pounds of trout (conversion of 3.0);
33.3 (pounds of trout produced) x 13.7 (percentage of protein in hatchery trout) = 4.6 pounds of body protein in hatchery trout;
28.5 (pounds of protein fed) ÷ 4.6 (pounds of protein produced) = 6.2 pounds of food protein required to produce 1 pound of body protein.

Although the literature indicates that the average conversion for natural food is 4.9 (6 experiments with a range of 2.3 to 7.1) under experimental conditions, a total of 6.0 pounds of natural food per pound of wild trout produced is assumed in order to place a bias against natural food. The calculations are:

100 pounds of natural food provide 11.5 pounds of protein (percentage of protein in natural food);
100 pounds of natural food produce 16.7 pounds of wild trout (conversion of 6.0);
16.7 (pounds of wild trout produced) x 21.2 (percentage of protein in wild trout) = 3.5 pounds of body protein produced in wild trout;
11.5 (pounds of natural-food protein fed) ÷ 3.5 (pounds of body protein produced) = 3.3 pounds of natural-food protein required to produce 1 pound of body protein.

Thus, assuming a total conversion of 6.0 for natural food and 3.0 for hatchery food, the efficiency of natural food in terms of body protein produced is almost twice that of hatchery food.

Although management practices establish the protein level in trout hatchery diets utilizing dry concentrates at between 28 and 30 percent, there is belief that such levels are higher than necessary. The accepted dietary level for hatchery foods is based upon the protein content of diets producing satisfactory growth rates and total conversions. The protein required in other types of animal husbandries ranges from 14 to 22 percent of the diet. Invariably trout diets composed of meats and dry concentrates and containing such low levels of protein produce inferior growth and increase the total conversion. That trout can grow efficiently on low-level protein foods seems established by the production efficiency of natural foods which contain only 11.5 percent protein. There are several possible reasons for the established high protein content of hatchery diets. Hatchery diets may lack unknown vitamins that are necessary for growth and protein utilization. The protein quality of natural foods may be superior to that of hatchery foods, accounting for the more efficient utilization of protein in natural foods. On the other hand, the protein quality of hatchery diets may equal that of natural food, but during the mechanics of feeding some of the protein may be lost because of leaching of the more soluble fractions of protein. Such losses could lower the protein quality of

the diet and reduce efficiency, even though the diet is adequate in every respect before it is fed. None of these analyses of hatchery trout pertains to trout fed a pelleted fish food. It is probable that less food is lost in feeding pellets, and thus that prevention of leaching of dietary ingredients would increase the efficiency of the production of trout flesh. This is supported in part by the low conversions of food into fish flesh (2.0 to 2.5) when pellets are fed to trout. Pelleted hatchery foods offer an opportunity to reduce the protein level in the food and--because protein is the most expensive ingredient--to lower the cost per pound of hatchery diets.

It is possible that natural food is more completely absorbed than hatchery food because of more efficient digestion, and thus that a greater portion of natural food is utilized.

In natural habitats, foods that approach hatchery diets in chemical content (other fish, for example) are available to the trout; but many workers have reported that the types of invertebrates represented in the averages of the table form 90 to 99 percent of the food eaten by brook trout less than 6 inches in length, within the size range of the brook trout used in these studies (Juday 1907, Clemens 1928, Needham 1930, Lord 1933). The comparisons between the two groups of food are considered valid.

For several reasons, these comparisons of the effect of food source on the chemical composition of the body of trout must be considered speculative. Although the size of the wild fish is known, the exact age of the trout is unknown, and age might be a contributing factor. In addition, hatchery trout are fed a specified amount of food daily, whereas the intake of wild trout is not controlled. However, in view of the fat content of the two groups of trout (3.4 percent for wild and 5.5 for hatchery), it is doubtful that underfeeding is a factor in the results obtained with wild trout. Exercise could be a most important cause of variance, and undoubtedly wild trout receive more exercise than hatchery trout do. Some of the samples used in these studies were taken from lakes, however, and there is no outstanding difference between these trout and trout taken from streams. Presumably trout from lakes would receive exercise similar to that of hatchery trout in ponds.

The analytical results certainly point toward the superiority of natural foods over hatchery diets, even though the natural food was not "fed" under precise experimental conditions. After years of study the rations now used for domesticated animals are considered superior to the "natural" food of these animals. It is reasonable to expect that, as research on trout nutrition progresses, the time will come when the food fed to trout in hatcheries will be superior in all respects to natural food.

Acknowledgments

For the samples of wild brook trout received for use in this study, the authors are indebted to the following cooperators: J. G. Appelget, Dr. R. E. Lennon, R. S. Nielson, and A. H. Swartz of the Fish and Wildlife Service; Dr. J.-P. Cuerrier of the Canadian Wildlife Service; Dr. A. H. Hazzard of the Pennsylvania Fish Commission; and Dr. D. A. Webster of Cornell University.

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THE STONEROLLER IN THE SMOKIES

The stoneroller (Campostoma anomalum) may be the most abundant fish in the streams of the Great Smoky Mountains National Park. In some of the Park's major watersheds, such as Little River and Little Pigeon River, the stoneroller outnumbers and outweighs the trout.

R. E. Lennon, biologist in charge of Eastern Federal Waters Investigations for the U. S. Fish and Wildlife Service, has reported as follows:

"In 1954 the stoneroller population in Little River was estimated at 1,151 fish (71.5 pounds) per acre, as opposed to 349 rainbow trout (29.8 pounds) per acre. This judgment of the two populations has been substantiated by the fact that during a single month in the fall of 1956 collectors working at the survey stations on Little River secured 3,100 stonerollers and only 1,100 trout. As many as 1,000 stonerollers have been collected at individual 100-yard stations on some streams in the Park.

"The stoneroller is herbivorous, and its local abundance in the Smokies attests to the great production of periphyton in these extremely soft waters. The stoneroller inhabits the rough as well as the flatter waters. It is noteworthy, however, that no such concentrations of this species have been observed by us in trout waters of Virginia or West Virginia."

PRODUCTION DURING INTENSIVE CARP CULTURE IN JAPAN

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IN JAPAN, THE CARP is eaten with relish and is popular among the people. A traveler in any part of Japan will see carp farms frequently. In general, those farms contain stagnant-water ponds where from 1 to 4 kilograms of carp per tubo are being reared.[1/] But, in the running-water ponds that are observed in special regions in Japan, carp are raised intensively and many more carp per tubo are produced.

About 50 miles northwest from Tokyo is Takasaki City. In the suburb of this city there is a pond, famous for intensive carp culture, belonging to Mr. Y. Tanaka. There 400 kilograms or more of carp per tubo are being raised. Such an extraordinary amount of carp is produced only in this pond, although a great portion of it can be reared in other running-water ponds.

The method for increasing the production of carp in this farm has been achieved through the enthusiastic endeavor of Mr. T. Tanaka, father of the present owner. At this time, Mr. Y. Tanaka is managing this farm in the same way his father did.

The writer has studied the relation between the productive capacity and the various conditions of this farm.

Conditions of the Ponds

All the ponds of this farm are beside a small stream that is called Itahana. This stream is a branch of the Usui River.

For convenience in study, the writer selected two ponds situated on the left side of the uppermost waters of the stream and named them Pond No. 1 and Pond No. 2.

In general, the shapes of the ponds of this farm are different, determined by the conditions around them. The two ponds selected for study are triangular in shape, and their longest sides run almost parallel with the side of the stream (see map). Mr. Tanaka has said that the triangular shape of the pond is best for production.

Pond No. 1 is 14.6 tubos in area, and Pond No. 2 is 4.1 tubos in area. The depth of the water is about 1.7 meters. The walls around the ponds are made of concrete and stone blocks, 2 meters in height. The bottoms are mud. The water current at A (see map), a point above the inlet gate of Pond No. 1, is about 0.3 meter per second; the water current of the lower part from the inlet is about 1.2 meters per second. This difference is supposed to be caused by rapid deepening of the pond. A whirlpool has been observed along the longest side of the pond.

The velocity of the flow at C, a point above the inlet gate of Pond No. 2, is 0.2 meter per second. The water runs

[1/] 1 tubo = 3.3058 square meters.

In view of increasing interest in carp and buffalo production in some sections of the United States, the production rate that is described here for carp--approximately 1.33 million pounds per acre--presents a challenge. As a raceway rather than a pond type of rearing, to be compared with our production of cold-water species such as trout, this production rate--less than 3 pounds per gallon per minute of flow, less than 6 pounds per cubic foot of raceway volume--is not phenomenal. The EDITORS.

into Pond No. 2 from the branch stream after mingling with outlet waters from B and X (drainage of the other ponds).

In the spring, the caretakers begin to rear young carp (about 30 to 70 grams in weight) in these ponds, starting to feed these fish when the temperature reaches 16° C. The rearing period is always continued for about 210 days after the day on which food is given for the first time.

The pond water is transparent in autumn but somewhat muddy in summer. Almost no green plankton can be seen at any time.

Of special interest is the method used in this intensive carp culture. Definite quantities and qualities of fish foods are given to the carp to increase their body weight about 10 times during these 210 days. This method also was devised by Mr. T. Tanaka after much experience.

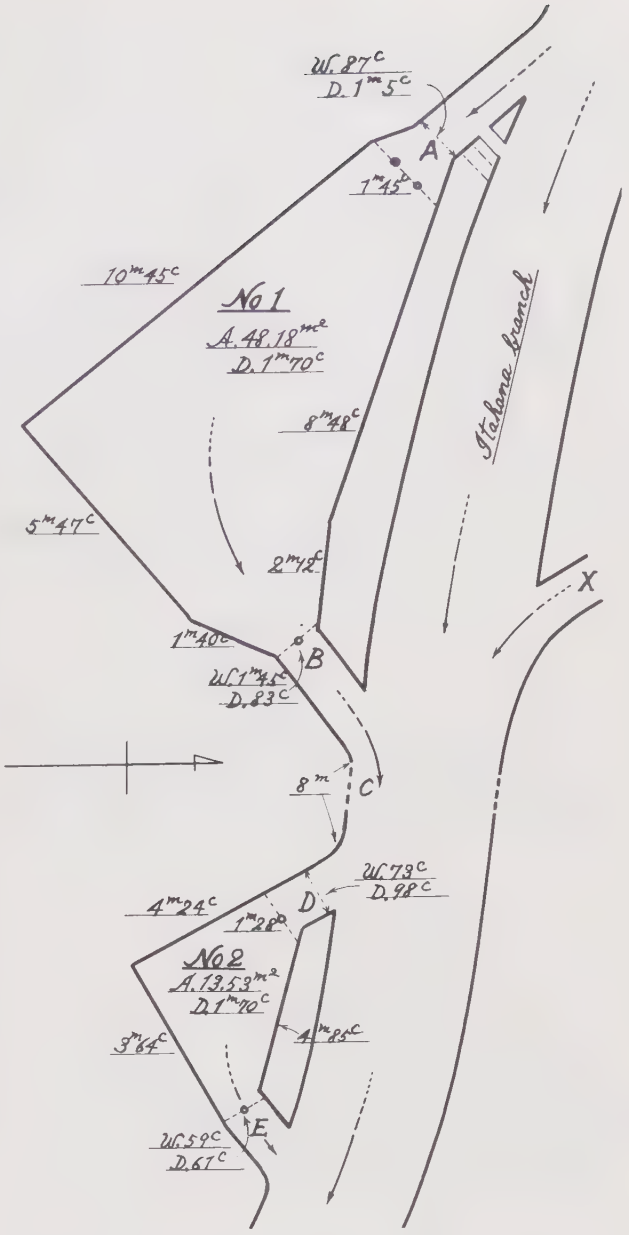
The foods used for this culture include raw silkworm pupae, pressed barley, and many kinds of fresh-water worms. The details regarding these foods were reported by Mr. T. Tanaka (1928).

In the summer, the temperature of the water in the ponds sometimes reaches 32° C. or higher. The carp do not eat during periods of such high temperature. Sometimes, therefore, the carp are given food every 2 hours during the night under electric lamps, after the temperature of the water has fallen to 25° or 24° C.

If such a definite procedure for rearing the carp is not carefully followed, the carp cannot be expected to grow--and some of them may be affected by disease.

Production in Two Ponds

The production in these two ponds from April 1954 to early in the spring of 1955 is shown in table 1.



Map of ponds studied in Mr. Tanaka's fish farm.

(Courtesy of the author)

TABLE 1.--The weights of carp at the end of April 1954 and at the harvest in 1955

Pond	Number of carp reared	At the end of April, 1954: Average body weight (grams)	At the end of April, 1954: Total weight reared (kilograms)	On January 27, 1955: Total weight harvested (kilograms)
No. 1 ---------	8,179	62.6	512.2	5,591.6
No. 2 ---------	3,113	24.2	75.4	1,142.6

On October 10, during the rearing season, 1,875 kilograms of carp (average weight, 843.7 grams) were removed from Pond No. 1 and sent to the market. Thus, the total productivity in Pond No. 1 in this year was

$$5{,}591.6 + 1{,}875 = 7{,}466.6 \text{ kg.}$$

It was estimated that the productivity of the pond was reduced about 5 percent by irritating the fish. Yet the average body weight of the carp was 937.5 grams at the end of that period of culture. If the carp had not been removed from the pond at that time, the productivity of the pond would have been increased by 5 percent. Then, the true harvest at the end of the period of culture (January 27, 1955) may be calculated as follows:

$$7{,}466.6 + (5{,}591.6 \times 0.05) = 7{,}746.2 \text{ kg.} \quad \text{--- (1)}$$

The average weight of the carp per tubo at the beginning of the rearing season may be calculated from the data in table 1 and may be shown as follows:

$$\left.\begin{array}{l} \text{Pond 1: } \dfrac{512.2}{14.6} = 35.1 \text{ kg.} \\ \text{Pond 2: } \dfrac{75.4}{4.1} = 18.4 \text{ kg.} \end{array}\right\} \text{--------- (2)}$$

The average increment of the production of carp per tubo in these ponds during this period may be calculated from the data in table 1 and equation (1) and may be shown as follows:

$$\left.\begin{array}{l} \text{Pond 1: } \dfrac{7{,}746.2 - 512.2}{14.6} = 495.5 \text{ kg.} \\ \text{Pond 2: } \dfrac{1{,}142.6 - 75.4}{4.1} = 260.3 \text{ kg.} \end{array}\right\} \text{(3)}$$

Then, on the basis of the data of equations (2) and (3), the rates of increment of weight per tubo during this period may be shown as follows:

$$\left.\begin{array}{l} \text{Pond 1: } \dfrac{495.5}{35.1} = 14.12 \text{ times} \\ \text{Pond 2: } \dfrac{260.8}{18.4} = 14.16 \text{ times} \end{array}\right\} \text{------ (4)}$$

The data in equation (4) indicate that the rates of production of the two ponds were almost the same.

The average current velocities at the upper points of outlet gates B and E were determined by Hiroi's current meter to be as follows:

B point: 30 cm./sec. (average, 3 data)
E point: 16.5 cm./sec. (average, 3 data)

The areas of the cross sections of B and E were as follows:

B point: 12,035 sq. cm.
E point: 6,935 sq. cm.

Then, the volumes of water passing through gates B and E per second may be calculated as follows:

$$\left.\begin{array}{l} \text{B point: } 12{,}035 \times 30 = 361.6 \text{ liters} \\ \text{E point: } 6{,}935 \times 16.5 = 102.9 \text{ liters} \end{array}\right\} \text{-(5)}$$

The volumes of water passing through 1 tubo per second for each pond may be presented as follows:

$$\left.\begin{array}{l} \text{Pond 1: } \dfrac{361}{14.6} = 24.7 \text{ liters} \\ \text{Pond 2: } \dfrac{114}{4.1} = 25.1 \text{ liters} \end{array}\right\} \text{------- (6)}$$

The data in equation (6) show that the volume of water passing through 1 tubo per second in Pond No. 2 was larger than the volume of water passing through 1 tubo per second in Pond No. 1.

In order that the water might not be disturbed by the violent motion of the carp in getting their food quickly, physical and chemical studies in both ponds were completed before the daily feedings. The results are shown in table 2.

In table 2, the oxygen content of the water was determined by Winkler's method, the pH by Merck's universal indicator, and the nitrogen in ammonium and phosphorus in phosphate by the colorimetric methods, respectively.

Discussion

From the data in equation (5) regarding volume of water per second passed through

TABLE 2.--Physical and chemical data of Pond No. 1 and Pond No. 2

Pond	Point	Water temperature °C.	pH	Oxygen content (cubic centimeters)	Nitrogen in ammonium (gamma per liter)	Phosphorus in phosphate (gamma per liter)
No. 1	A	17.5	8.25	Surface -- 6.99	68.2	4.9
			8.20	0.58 m. -- 6.99		
	B	17.5	8.20	Surface -- 6.56	85.1	4.5
			8.20	Bottom -- 6.49		
No. 2	C	17.3	9.00	Middle -- 6.34	72.8	8.7
	D	18.0	8.25	Middle -- 6.13	92.6	11.3

these two ponds and the data in table 2 regarding oxygen content of the water in these ponds, the total volume of oxygen entering each of the ponds per hour may be calculated as follows:

$$\left.\begin{array}{l}\text{Pond 1: } 361.6 \times 6.99 \times 60 \times 60 = 9{,}097 \text{ liters} \\ \text{Pond 2: } 102.9 \times 6.34 \times 60 \times 60 = 2{,}347 \text{ liters}\end{array}\right\} \quad (7)$$

The total weights of the carp being reared in these ponds in mid-October, when the chemical analyses were undertaken, may be estimated as 90 percent of the weights at the end of the culture period (see equation (1) and table 1). The estimated total weights of carp in these ponds in mid-October, therefore, may be represented as follows:

$$\left.\begin{array}{l}\text{Pond 1: } 1{,}875 + 0.90\,(5{,}591 + 0.05 \times 5{,}591) = 7{,}158 \text{ kg.} \\ \text{Pond 2: } 1{,}142 \times 0.90 = 1{,}028 \text{ kg.}\end{array}\right\} \quad (8)$$

The amount of oxygen used by a carp varies in accordance with the conditions studied, but at this time the writer has employed Knauthe's datum. Knauthe reported (see Leiner 1938: 35) that the oxygen consumption of a carp (body weight, 206 grams) per kilogram per hour was 89.7 cubic centimeters at 15.4° C.

Then, the total oxygen consumption per hour of all the carp in these ponds at mid-October may be shown as follows:

$$\left.\begin{array}{l}\text{Pond 1: } 7{,}158 \times 89.7 = 642 \text{ liters} \\ \text{Pond 2: } 1{,}028 \times 89.7 = 92 \text{ liters}\end{array}\right\} \quad (9)$$

From data in (7) and (9), it is possible to compare the volume of oxygen per hour in all waters entering the ponds with the oxygen consumption per hour of all the carp in those ponds. This relationship may be shown as follows:

$$\left.\begin{array}{l}\text{Pond 1: } \dfrac{9{,}097}{642} = 14.2 \text{ times} \\ \text{Pond 2: } \dfrac{2{,}347}{92} = 25.5 \text{ times}\end{array}\right\} \quad (10)$$

At this time, oxygen in the air may penetrate the surface of the water. This, however, is negligible when compared with the amount of oxygen that is in the water.

These data show that more oxygen was in the water entering the ponds than was required by all the carp in those ponds. The amount of oxygen consumed by carp depends upon the particular conditions, as already noted. It is not clear what condition prevailed when Knauthe observed the datum previously mentioned. However, this writer presumes that the carp were active. In those days the closed-system respiration apparatus, like that of Zuntz, was employed; and in such a respiration chamber the carp always had to be very active. Spoor's study (1946) showed that the amount of oxygen consumed increased linearly in accordance with increasing

activity. At present, this writer cannot explain the relation between Spoor's results and the active condition of the carp in Knauthe's experiment. Nevertheless, there was no lack of oxygen in these two ponds even during the great activity of the carp at feeding time, as there was much more oxygen in the ponds than the carp required (see equation (10)).

Moreover, the high pH values in the waters of these ponds (table 2) indicate that there is no reason for anxiety about the effect of carbon dioxide.

Krogh and Leitch (1919) reported that the values of tu (tension of unloading) and tl (tension of loading) of the carp blood were from 2 to 3 millimeters and 10 millimeters, respectively, of mercury. This indicates a strong affinity of carp blood to oxygen.

In general, the rate of production in a pond is better when the concentration of fish is lower--as Yoshiwara (1953) has reported--and the concentration of oxygen is higher. Therefore, the production rate in Pond No. 2 might have been expected to be higher than that in Pond No. 1, since in Pond No. 2 the fish were less crowded (2) and the oxygen supply was larger (10). However, the rates of increment of the weight of carp during this period were almost the same, as is shown in equation (4).

The writer has concluded that excretory substances from the carp may keep down the production in the ponds. The amounts of nitrogen in ammonia and of phosphorus in phosphate increased at the outlets of the ponds and were greater in Pond No. 2 than in Pond No. 1. Ivlev (1935) and Brockway (1950) reported that the production of fish was reduced by the presence of excretory substances in the water. It is generally true that production is largest in the uppermost of a series of ponds fed by the same stream. Then, these results may have been due to substances excreted by the fish reared in the pond rather than to the oxygen, carbon dioxide, pH, and density of fish in the water. Further study must be given to the relation between the production and the surface area of the pond.

Summary

1. Various conditions of an intensively managed carp farm were studied, and its productivity was considered from the physiological point of view.

2. The rate of production of carp was higher in this farm than in any other farm in our country.

3. There was much more oxygen in the water entering the ponds than was needed by the carp.

4. Because of the high values of pH in the water, it is believed that in these ponds carbon dioxide did not affect the carp.

5. The rate of production in the ponds may have been affected by the presence of substances excreted by the carp.

6. It is believed that, for increased production of carp, removal of excretory substances is more important than factors such as oxygen or carbon dioxide in the water.

Acknowledgments

The writer wishes to offer his hearty thanks to Dr. Nakamura, director, and to T. Miyajima and J. Higashii, members of the Branch Laboratory of the Inland Water Fisheries Research, who assisted in the chemical analyses.

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NEUTRALIZING ELECTROSTATIC CHARGE ON ROLLING-MILL SCALE PRESS

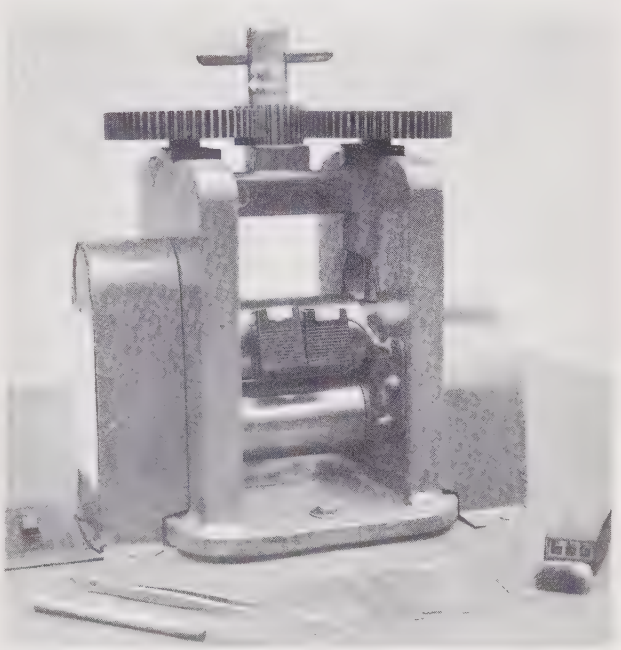
The desirability of using radioactive lens brushes on a rolling-mill scale press to facilitate the preparation of plastic impressions of fish scales has been pointed out by Leon D. Johnson of the Wisconsin Conservation Department.

When used without modification to make impressions of fish scales for a research project (F-10-R-1, "Exploitation Rates of Warm-Water Fishes in Northern Wisconsin") in the Federal Aid to Fish Restoration program, the rolling-mill scale press produced very fine impressions. Action of steel rollers on the plastic slides, however, created an electrostatic charge on the press, fish scales, and slides. Thus when the scales were put on the slides and brought close to the rollers, the scales upended or jumped off. Then the operator had the additional work of recovering the fish scales for another try at making the impressions.

From his office in Spooner, Wisconsin, Mr. Johnson offers this suggestion:

"A simple method of dissipating the charge has been to mount Staticmasters (brushes with strips of radioactive polonium, obtainable at any photographic store) on one side of the top roller at the point where slides are fed to the rollers.

"Two 1-inch brushes are fine on the scale press in the photograph. For use, the plastic handle of the brush is sawed off in the middle, the bristles are removed, and a hole is bored through the brush so that it can be mounted on heavy wire. A 1/4- by 3/4-inch buttonhead bolt, set into a 1/4-inch hole tapped (threaded) in the side of the press frame, secures to it a clothesline wire bracket. The wire is put through the holes in the brushes and positioned so that they clear the front of the top roller."



(Courtesy of Mr. Johnson)

FISH FOODS PURCHASED FOR FEDERAL HATCHERIES IN 1955, COMPARED WITH 1945 AND 1949

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IN THE CALENDAR YEAR 1955, the hatcheries of the Fish and Wildlife Service purchased almost 6 million pounds of meat, fish, and dry products, primarily for the feeding of trout and salmon. A minor portion of the total was used to feed warm-water species.

As shown in the table, the total of fish foods purchased in 1955 is in sharp contrast to the purchases of 1.5 and 1.8 millions of pounds in 1945 and 1949, respectively, as reported by Tunison (1951). During the same periods the production in pounds of trout and salmon increased materially: in 1945, the production was 462,561 pounds; in 1949, 598,978 pounds; and in 1955, 1,781,881 pounds. It should be noted, however, that the foods reported here are those purchased and not necessarily those fed in the year of purchase.

The constantly increasing requirement for catchable-size trout for the stocking of Federal waters and the expansion of the salmon program to meet the threat of dams on the west coast were responsible for the greatly increased production. The expansion of existing facilities and the erection of a few new hatcheries provided the space for additional production. Also to be considered is the dietary improvement that resulted in a more favorable conversion of food to fish, as well as the ability to produce more pounds of fish per cubic foot of rearing space, and per gallon of water inflow, with more modern methods.

The fish foods purchased for Federal hatcheries in 1955 were about 227 percent greater than the 1949 purchases. Fiedler and Samson (1935) reported that the fish food utilized in 1934 by 676 State, Federal, and commercial fish hatcheries totaled 11,455,000 pounds valued at $608,000. In 1949, Tunison and others reported that the hatcheries of 38 States and the Federal hatcheries used almost 30 million pounds of fish food valued at $2,194,000. Commercial hatcheries were not included in the 1949 survey, nor in Tunison's report (1951) of fish foods purchased in 1945 and 1949 for Federal hatcheries. On the basis of the information available, it is believed that the Federal, State, and commercial hatcheries of the United States purchased, in 1955, some 100 million pounds of fish foods at a cost of about 8 million dollars.

The utilization of fish foods at the Federal hatcheries (as well as at other hatcheries) has been dictated by availability and cost. Significant advances in the field of fish nutrition have directed attention to the desirability of feeding foods that will produce high-quality fish at reasonable cost.

The changed emphasis in fish-food purchases is interesting. Dry meals and, where available, fish products have displaced meat products to a great extent. Pellets appear to be well on the way to becoming the popular food, requiring a minimum of labor and of capital investment. Pellets are not the whole answer, but they can be expected to improve and to provide the basic nutritive requirements in the next few years. Perhaps

FISH FOOD PURCHASED IN 1955
compared with 1945 and 1949 totals 1/

A. MEAT PRODUCTS 2/

Kind of food	Regions I	II	III	IV	V	Totals 1945	1949	1955
Beef liver, fresh								
Pounds	--	12,928	278	--	10,525	4,243	--	23,731
Cost	--	$1,396	$53	--	$1,353	$875	--	$2,802
Average cost	--	$0.11	$0.19	--	$0.13	$0.21	--	$0.12
Beef liver, condemned								
Pounds	502,835	126,573	101,254	31,718	212,129	212,182	281,265	974,509
Cost	$63,242	$16,161	$12,823	$4,292	$26,684	$20,514	$34,339	$123,202
Average cost	$0.13	$0.13	$0.13	$0.14	$0.13	$0.10	$0.12	$0.13
Pork liver, condemned								
Pounds	226,779	--	--	--	--	40,703	140,999	226,779
Cost	$23,714	--	--	--	--	$3,142	$12,907	$23,714
Average cost	$0.10	--	--	--	--	$0.08	$0.09	$0.10
Horse liver, fresh								
Pounds	--	--	--	--	--	3,611	22,998	--
Cost	--	--	--	--	--	$396	$2,459	--
Average cost	--	--	--	--	--	$0.11	$0.11	--
Livers, mixed, condemned								
Pounds	--	48	--	--	--	--	18,154	48
Cost	--	$5	--	--	--	--	$2,554	$5
Average cost	--	$0.10	--	--	--	--	$0.14	$0.10
Beef spleen								
Pounds	87,832	168,115	15,095	97,353	183,780	160,518	132,148	552,175
Cost	$7,665	$14,940	$1,304	$8,948	$15,028	$8,248	$14,150	$47,885
Average cost	$0.09	$0.09	$0.09	$0.09	$0.08	$0.05	$0.11	$0.09
Pork spleen								
Pounds	73,000	2,639	92,699	31,893	104,694	142,763	117,218	304,925
Cost	$7,032	$245	$7,608	$3,032	$9,469	$9,387	$14,916	$27,386
Average cost	$0.10	$0.09	$0.08	$0.10	$0.09	$0.07	$0.13	$0.09
Spleen, mixed								
Pounds	171,696	--	--	--	144,690	3,781	94,910	316,386
Cost	$14,805	--	--	--	$11,283	$282	$8,954	$26,088
Average cost	$0.09	--	--	--	$0.08	$0.07	$0.09	$0.08

(Footnotes at end of MEAT PRODUCTS section of table)

FISH FOOD PURCHASED in 1955 (continued)
compared with 1945 and 1949 totals

A. MEAT PRODUCTS (Continued)

Kind of food	Regions I	II	III	IV	V	Totals 1945	1949	1955
Beef heart								
Pounds	9,598	--	--	--	--	3,506	--	9,598
Cost	$1,039	--	--	--	--	$513	--	$1,039
Average cost	$0.11	--	--	--	--	$0.15	--	$0.11
Beef lungs								
Pounds	216,058	--	--	--	--	21,398	22,332	216,058
Cost	$15,296	--	--	--	--	$731	$465	$15,296
Average cost	$0.07	--	--	--	--	$0.03	$0.02	$0.07
Tripe								
Pounds	11,305	--	--	--	--	30,916	28,600	11,305
Cost	$565	--	--	--	--	$583	$429	$565
Average cost	$0.05	--	--	--	--	$0.02	$0.02	$0.05
Horse meat								
Pounds	3,237	972	--	--	--	167,487	219,299	4,209
Cost	$196	$49	--	--	--	$8,184	$13,645	$245
Average cost	$0.06	$0.05	--	--	--	$0.05	$0.06	$0.06
Meats, miscellaneous and unclassified								
Pounds	3/ 350	4/ 53,464	--	5/ 2,096	--	6/ 204,215	108,338	55,910
Cost	$49	$1,898	--	$182	--	$11,487	$9,303	$2,129
Average cost	$0.14	$0.04	--	$0.09	--	$0.06	$0.09	$0.04
TOTALS-Meat products								
Pounds	1,302,690	364,739	209,326	163,060	655,818	995,323	1,186,261	2,695,633
Cost	$133,603	$34,694	$21,788	$16,454	$63,817	$64,342	$114,121	$270,356
Average cost	$0.10	$0.10	$0.10	$0.10	$0.10	$0.06	$0.10	$0.10

1/ All computations to the nearest pound, dollar and cent.
2/ Not including animal meals reported under DRY FEEDS.
3/ Condemned sheep liver, 350 lbs. at $0.14 or $49.
4/ Includes tankage, canned dog & cat foods, meat and bone scrap and meals and 15,684 pounds of animal and fowl blood at $0.01 per pound or $193, all used primarily for warm-water species.
5/ Principally canned dog food for warm-water species, and 130 pounds fresh sheep liver at $0.12 per pound or $16.
6/ Includes condemned sheep liver, 1740 lbs. at $0.08 or $146, and the following 1945 items of which there were no purchases in 1949 or 1955: sheep liver, fresh, 461 lbs., $0.22, $100; pork liver, fresh, 14 lbs., $0.14, $2; beef plucks, 17,442 lbs., $0.04, $624; horse plucks, 18,905 lbs., $0.01, $159.

FISH FOOD PURCHASED IN 1955 (continued)
compared with 1945 and 1949 totals

B. DRY FEEDS

Kind of food	Regions I	II	III	IV	V	Totals 1945	1949	1955
Skim milk, dried								
Pounds	--	26,450	--	14,000	18,450	42,549	23,760	58,900
Cost	--	$1,456	--	$2,100	$858	$3,789	$2,987	$4,414
Average cost	--	$0.06	--	$0.15	$0.05	$0.09	$0.13	$0.07
Meal, fish								
Pounds	170,530	59,835	--	--	88,615	79,093	112,222	318,980
Cost	$13,259	$6,665	--	--	$6,765	$3,406	$9,846	$26,689
Average cost	$0.08	$0.11	--	--	$0.08	$0.04	$0.09	$0.08
Meal, cottonseed								
Pounds	115,200	[1]/74,000	--	[1]/2,800	87,115	79,433	57,837	279,115
Cost	$5,404	$3,115	--	$138	$4,057	$2,660	$2,637	$12,714
Average cost	$0.05	$0.04	--	$0.05	$0.05	$0.03	$0.05	$0.05
Meal, soybean								
Pounds	--	--	--	[1]/4,951	--	4,838	--	4,951
Cost	--	--	--	$231	--	$154	--	$231
Average cost	--	--	--	$0.05	--	$0.03	--	$0.05
Wheat middlings								
Pounds	115,860	75,790	--	1,700	85,315	72,755	60,702	278,665
Cost	$2,825	$2,636	--	$57	$3,331	$2,293	$2,182	$8,849
Average cost	$0.02	$0.04	--	$0.03	$0.04	$0.03	$0.04	$0.03
Flour, red dog								
Pounds	--	--	--	--	35,800	19,497	--	35,800
Cost	--	--	--	--	$1,448	$483	--	$1,448
Average cost	--	--	--	--	$0.04	$0.02	--	$0.04
Salt								
Pounds	24,085	10,400	600	--	17,653	12,634	18,129	52,738
Cost	$370	$202	$12	--	$292	$152	$260	$876
Average cost	$0.02	$0.02	$0.02	--	$0.02	$0.01	$0.01	$0.02
Open-formula mixtures								
Pounds	[3]/44,945	[2]/1,636	[4]/135,800	[5]/136,791	[6]/21,100	12,799	120,735	340,272
Cost	$2,833	$714	$11,226	$11,526	$1,149	$645	$10,626	$27,448
Average cost	$0.06	$0.06	$0.08	$0.08	$0.06	$0.05	$0.09	$0.08

(Footnotes at end of DRY FEEDS section of table)

FISH FOOD PURCHASED IN 1955 (continued)
compared with 1945 and 1949 totals

B. DRY FEEDS (continued)

Kind of food	Regions I	II	III	IV	V	Totals 1945	1949	1955
Distillers solubles, dried								
Pounds	102,600	28,000	2,900	--	122,515	--	816	256,015
Cost	$5,477	$2,055	$199	--	$6,515	--	$35	$14,246
Average cost	$0.05	$0.07	$0.07	--	$0.05	--	$0.04	$0.06
Yeast, dried								
Pounds	--	1,900	2,400	--	--	--	--	4,300
Cost	--	$673	$1,216	--	--	--	--	$1,889
Average cost	--	$0.35	$0.51	--	--	--	--	$0.04
Pellets								
Pounds	7/295,462	7/32,450	4/144,000	7/2,150	8/15,000	--	--	489,062
Cost	$25,084	$2,872	$11,577	$94	$1,551	--	--	$41,178
Average cost	$0.08	$0.09	$0.08	$0.04	$0.10	--	--	$0.08
Miscellaneous unclassified								
Pounds	9/950	10/6,857	11/2,000	--	--	12/77,990	12/25,775	9,807
Cost	$625	$350	$297	--	--	$1,932	$2,530	$1,272
Average cost	$0.65	$0.05	$0.15	--	--	$0.02	$0.10	$0.13
TOTALS-DRY FEEDS								
Pounds	869,632	317,318	287,700	162,392	491,563	401,588	419,976	2,128,605
Cost	$55,877	$20,738	$24,527	$14,146	$25,966	$15,514	$31,103	$141,254
Average cost	$0.06	$0.07	$0.09	$0.09	$0.05	$0.04	$0.07	$0.07

1/ Includes some meal used as fertilizer in warm-water ponds.
2/ Includes 536 pounds of "Cortland-mix" pellets.
7/ Principally commercial pellets.
9/ Cellulose gum (CMC) used as food binder.
10/ Includes purina, mash, bread (for warm-water species)
11/ Commercial mixture
12/ Includes bone & meat meals, buttermilk, flour, meat scrap & paprika.

Custom formulae (in percent)	(3/)	(4/)	(5/)	(6/)*	(8/)
Whitefish meal	--	16	--	--	--
Herring meal	24	--	--	--	--
Fish meal, unidentified	--	--	28	24	40
Cottonseed meal	24	24	24	24	15
Wheat middlings	24	24	--	24	25
Red dog flour	--	--	24	--	--
Dried skim milk	--	11	--	--	7
Distiller's solubles, corn	24	13	10	24	--
Brewers' yeast	--	10	10	--	10
Salt	4	2	4	4	--
Cod liver oil	--	--	--	--	3
	100	100	100	100	100

*Essentially the dry mix prepared at Region V hatcheries from ingredients purchased separately.

FISH FOOD PURCHASED IN 1955 (continued)
compared with 1945 and 1949 totals

C. FISH PRODUCTS 1/

Kind of food	Regions I	II	III	IV	V	Totals 1945	1949	1955
Salmon flesh								
Pounds	305,986	--	--	--	--	68,079	33,391	305,986
Cost	2/$3,174	--	--	--	--	$1,976	$500	$3,174
Average cost	$0.01	--	--	--	--	$0.03	$0.01	$0.01
Salmon viscera								
Pounds	349,940	--	--	--	--	31,778	120,041	349,940
Cost	$22,045	--	--	--	--	$706	$9,224	$22,045
Average cost	$0.06	--	--	--	--	$0.02	$0.08	$0.06
Salmon eggs								
Pounds	224,297	--	--	--	--	--	--	224,297
Cost	$20,117	--	--	--	--	--	--	$20,117
Average cost	$0.09	--	--	--	--	--	--	$0.09
Turbot								
Pounds	150,000	--	--	--	--	--	--	150,000
Cost	$6,525	--	--	--	--	--	--	$6,525
Average cost	$0.04	--	--	--	--	--	--	$0.04
Miscellaneous and unclassified								
Pounds	3/1,200	4/14,491	--	5/1,510	--	26,314	20,564	17,201
Cost	$85	$970	--	$287	--	$1,416	$1,525	$1,342
Average cost	$0.07	$0.07	--	$0.19	--	$0.05	$0.07	$0.08
Cod liver oil 6/								
Pounds	3,017	816	428	--	1,182	--	--	5,443
Cost	$823	$212	$133	--	$284	--	--	$1,452
Average cost	$0.27	$0.26	$0.31	--	$0.24	--	--	$0.27
TOTALS-FISH PRODUCTS								
Pounds	1,034,440	15,307	428	1,510	1,182	126,171	173,996	1,052,867
Cost	$52,769	$1,182	$133	$287	$284	$4,098	$11,249	$54,655
Average cost	$0.05	$0.08	$0.31	$0.19	$0.24	$0.03	$0.06	$0.05

1/ Not including fish meals.
2/ Cost of preparation of spawned carcasses at hatcheries.
3/ Principally frozen anchovies.
4/ Live, fresh & frozen goldfish, carp & minnows for food for warm-water species. Cost represents, in part, hatchery labor utilized in field collection.
5/ Minnows.
6/ Does not include cod liver oil in custom dry mixtures and pellets.

FISH FOOD PURCHASED IN 1955 (continued)
compared with 1945 and 1949 totals

RECAPITULATION

Kind of food	Regions I	II	III	IV	V	Totals 1945	1949	1955
Meat products								
Pounds	1,302,690	364,739	209,326	163,060	655,818	995,323	1,186,261	2,695,633
Cost	$133,603	$34,694	$21,788	$16,454	$63,817	$64,342	$114,121	$270,356
Average cost	$0.10	$0.10	$0.10	$0.10	$0.10	$0.06	$0.10	$0.10
Dry feeds								
Pounds	869,632	317,318	287,700	162,392	491,563	401,588	419,976	2,128,605
Cost	$55,877	$20,748	$24,527	$14,146	$25,966	$15,514	$31,103	$141,264
Average cost	$0.06	$0.07	$0.09	$0.09	$0.05	$0.04	$0.07	$0.07
Fish products								
Pounds	1,034,440	15,307	428	1,510	1,182	126,171	173,996	1,052,867
Cost	$52,769	$1,182	$133	$287	$284	$4,098	$11,249	$54,655
Average cost	$0.05	$0.08	$0.31	$0.19	$0.24	$0.03	$0.06	$0.05
TOTALS								
Pounds	3,206,762	697,364	497,454	326,962	1,148,563	1/ 1,523,082	1/ 1,780,233	5,877,105
Cost	$242,249	$56,624	$46,448	$30,887	$90,067	$83,954	$156,473	$466,275
Average cost	$0.08	$0.08	$0.09	$0.09	$0.08	$0.06	$0.09	$0.08

1/ Commercial feeds totalling 65,657 in 1945, and 25,748 in 1949 not included.

PERCENTAGE ANALYSIS OF POUNDS OF FISH FOOD PURCHASED IN 1945, 1949 and 1955
(Percentages apply to individual columns in RECAPITULATION table above)

Kind of food	Percentage by regions and years I			II			III			IV			V			Percentage by yearly totals		
	1945	'49	'55	1945	'49	'55	1945	'49	'55	1945	'49	'55	1945	'49	'55	1945	1949	1955
Meat products																		
Percentage of total pounds	73	71	41	68	66	52	65	71	42	70	53	50	52	54	57	63	66	46
Dry feeds																		
Percentage of total pounds	1	8	27	25	34	46	33	29	58	30	46	50	40	46	43	25	23	36
Fish products																		
Percentage of total pounds	24	18	32	6	--	2	--	--	--	--	--	--	--	--	--	8	10	18
Commercial feeds	2	3	--	1	--	--	2	--	--	--	1	--	8	--	--	4	1	--

the use of meats, as such, will no longer be required.

The changeover from meat products to dry feeds and fish products is best illustrated in the percentage calculations on the last page of the table.

Additional trout and salmon hatcheries will be constructed and existing hatcheries will be enlarged to produce the fish required for management programs. There will be an ever-increasing demand for more foods for these fish. Competitive enterprises also will require more of these foods. The result may be the utilization of many products not now used for fish foods, increase in costs, and a more rapid shift to pellets.

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VARIOUS DRUGS AS AIDS IN SPAWNING RAINBOW TROUT

During 1954, Z. E. Parkhurst and M. A. Smith, fishery-management biologists of the U. S. Fish and Wildlife Service, made trials of five drugs--sodium amytal, tricaine methanesulfonate (M. S. 222), methyl pentynol, urethane, and chloretone--as aids in spawning rainbow trout. In each trial, one of the drugs was used in spawning 12 females and 8 males; a similar control lot was spawned without a drug.

Sodium amytal, because of its slow action, had no practical value in this work.

Tricaine methanesulfonate (M. S. 222), used at a concentration of 264 p.p.m., completely anesthetized the fish in 30 to 45 seconds. There was some mortality when rainbow trout were in this concentration longer, but it effectively increased the speed and ease of spawning when the operation was handled properly.

Methyl pentynol, used at a concentration of 2,400 p.p.m., had the trout sluggish, relaxed, and ready for spawning in 3.5 minutes. There were no ill effects if trout were in this solution a little longer.

Urethane (ethyl carbamate), used at a concentration of 0.5 percent (about 5,000 p.p.m.), had the trout partly anesthetized and ready for spawning in 2 minutes.

Chloretone (chlorbutanol), used at a concentration of 400 p.p.m., had the trout partly anesthetized in 1 to 1.5 minutes. Dissolving the crystalline form of chloretone in cold water is difficult, but a stock solution is easily made with warm water.

The water temperature during these trials was 43° F. An increase of only 2° or 3° may require more caution with some of these drugs, especially when marking small fingerlings. Also, fish in different water supplies may react differently to the same concentration of the same drug.

Of the trout used in these trials, 96.6 percent were in good condition 75 days after spawning. There was no evidence of significant difference in mortality associated with individual drugs.

The eggs of each trout were incubated separately. The 60 trout spawned with drugs had a hatch of 84.1 percent; the 12 untreated spawners, 84.0 percent. No significant difference was seen in percentile hatch associated with individual drugs.

Half of the trout--males and females--spawned with drugs were washed quickly in fresh water before spawning. There was no significant difference in hatch of eggs from washed and unwashed treated trout.

A METHOD OF USING AN ANESTHETIC IN MARKING FINS

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MARKING FINS OF FISH has become big business on the Pacific coast during the past few years. Approximately 20 million salmonoids have been marked by the various State and Federal fishery agencies in this area in the years 1950-55. During this period the Oregon Fish Commission has conducted 50 fin-marking projects in which 3,640,000 Pacific salmon (including spring chinook, fall chinook, sockeye, and silver salmon) and 502,000 steelhead trout have been marked. The usual fin-marking project has involved between 50,000 and 200,000 fish and has taken several markers many days to complete. The size of the fish has ranged from approximately 6 to 400 per pound.

When properly used, an anesthetic can save time and reduce fish injury (Foster 1941, Eschmeyer 1953). However, an anesthetic cannot be put to favorable use in large fin-marking projects without a method which will eliminate the risks incurred and still be convenient to use. The risks referred to are those of overexposure of the fish to the anesthetic and the possibility that the fish may smother from inadequate aeration of the solution.

The Oregon Fish Commission tried using an anesthetic at its Oxbow Hatchery in 1950 while marking fall chinook salmon; but because of lack of a suitable method for its use on a large scale, the anesthetic was not continued. No anesthetic was used in marking experiments from 1950 to 1954. Early in 1954 an anesthetic was tried at the Sandy River Hatchery while silver salmon were being marked. This time the anesthetic was administered in a closed recirculating system, as used by the Oregon Game Commission.[1/] After considerable experimentation a satisfactory method was developed.

Method and Equipment

Three regular hatchery troughs are used in the marking operations (figure 1). All three troughs are left in their normal positions in the hatchery except that troughs 1 and 2 are leveled to provide equal water depth at both ends.

Additional equipment needed includes a pump, an electric motor (1/3 horsepower, 1,750 revolutions per minute), wooden-framed bobbinet trays, hose, dip nets, egg baskets, hand tallies and holders, bone forceps, and a quantity of the anesthetic.

The outlet of trough 1 is plugged securely, the trough is filled with water to the desired level, and the intake valve is shut. The anesthetic is then added at the recommended concentration. The pump and motor, which deliver about 17 gallons of water per minute, are at the lower end of the trough (figure 1). The intake of the pump extends into the water almost to the bottom of the trough. A thin-walled hose is attached to the outlet of the pump and is run along the inside bottom of trough 2, which contains running water from the regular hatchery supply. This location of the hose has some effect in preventing the solution in trough 1 from warming up. The outlet of the hose is tied securely to the intake valve of trough 1, a few inches above the water level. Thus the solution

[1/] Oregon Game Commission. Unpublished data.

FIGURE 1.--Trough 1 contains the recirculating anesthetic solution, pump, motor, six marking trays.
Trough 2 contains six egg baskets in running water, with the return hose of trough 1 along inside bottom beneath the baskets.
Trough 3 contains six egg baskets in running water, each with an inverted egg basket as cover.

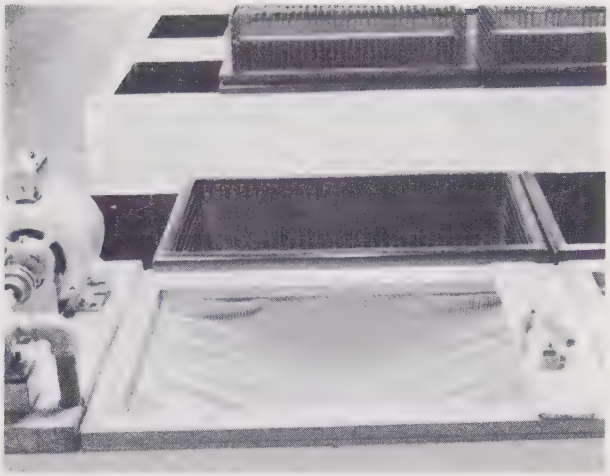

FIGURE 2.--Parts of three hatchery troughs and the equipment used in each for marking. Bobbinet tray is in foreground.

(Photographs courtesy of the author)

is pumped from the lower end of trough 1, through the hose in trough 2, and again into the upper end of trough 1. Screens at the intake and outlet areas of the trough keep debris and excised fins from clogging the pump.

Shallow nets are suspended above trough 1 from rectangular wood frames (figure 2). Each net, made of nylon bobbinet, is hung on a frame so that when it is used one way the bottom of the net is about 2 inches under water or, when the frame is inverted, is 3 to 4 inches below the surface. The former position is used when marking relatively small fish and the latter when marking larger fish. Removable wooden keepers on the lower side of each net frame keep it in place over the trough. A tally holder is mounted on each net frame to keep the tally within easy reach of the marker.

Trough 3 contains the egg baskets in which fish are held prior to their being marked. Egg baskets that are inverted over the fish prevent them from jumping out.

Lighting for the markers is provided by six 300-watt flood-reflector bulbs attached in parallel to a well-insulated heavy-duty cord suspended by metal clips from a tubular aluminum frame about 32 inches above trough 1. The frame is made of 5 pieces and can be assembled and put into operation quickly. The base of the frame is held to the trough by small C-clamps.

Procedure

The fish are brought into the hatchery building and placed in the baskets in trough 3. Six or fewer markers stand facing trough 1. As the markers need fish, they are taken from the stock baskets with a dip net by personnel directing the work. The dip net is allowed to drain a few seconds to minimize dilution of the solution in trough 1. Enough fish for about 10 minutes of marking are put in the bobbinet trays at one time. Before more fish are added, the markers' trays are completely emptied to prevent overexposure of the fish to the anesthetic. After being marked, the fish are placed in baskets in trough 2.

As fish marked by each marker are kept separate, frequent checks of individual

marking efficiency are possible. It has been demonstrated that improperly clipped fins regenerate to a large degree (Buser-Lahaye, reviewed, 1954). If the mark is too deep, it results in injury to the fish.

Individual length samples are easily obtained while the fish are still anesthetized. When a basket is comparatively full of marked fish, it is removed from the trough and the fish are returned to the hatchery ponds. At this time weight samples are also possible, or, if desired, all of the fish marked can be weighed.

Discussion

If the hatchery building is heated, the recirculating solution tends to become warmer than the running water. At such times it is advisable to add ice to the solution to prevent a temperature difference of more than 5° F. If it is necessary to add much ice, anesthetic must be added to maintain the solution at the correct concentration.

The pump should be allowed to run several minutes before any fish are placed in the markers' trays. This is a precautionary measure to insure proper mixing of the solution.

Urethane has been used as the anesthetizing agent by the Oregon Fish Commission, but this material is no longer used because recent information has indicated that it should be used with extreme caution. The most recent marking project of the Fish Commission was conducted with tricaine methanesulfonate (M. S. 222) as the anesthetic (Anonymous 1953). The results of this trial indicated that the tricaine methanesulfonate is as effective as urethane when used with the prescribed method.

Results

This method of applying an anesthetic in a closed system has been used in all of the fin-marking projects of the Oregon Fish Commission since 1954. Of the 50 projects mentioned in the first paragraph, the last 18 have been conducted with an anesthetic. These 18 markings have involved a total of 1,381,230 fish.

The marking rate for experiments without an anesthetic was compared with that for experiments in which an anesthetic was used according to the method described here. Conditions among these experiments varied greatly, however, making such a comparison difficult. The most important variables--location of fin (or fins) to be clipped, efficiency and experience of markers, and size and condition of the fish--influenced marking efficiency, particularly when no anesthetic was used. Nevertheless, as variations in conditions among experiments tended to cancel each other when all experiments were grouped, the following comparison is believed to be a good measure of the advantage of using an anesthetic in the way described:

Method	Fish marked	Hours marked	Fish per marker per hour	Fish per marker per day
With anesthetic	1,381,230	3,109	444	3,552
Without anesthetic---	2,760,659	9,299	297	2,376

Thus the marking rate increased from 297 fish per hour to 444, an increase of 147 fish, or 49.5 percent, per hour.

Eschmeyer (1953) found that the poorest markers were helped most by the use of the anesthetic and that the marks were more acceptable when the anesthetic was used. The results of these experiments are in accord with Eschmeyer's findings. The markers rapidly develop a "soft" touch when handling anesthetized fish, and this results in less squeezing of the fish.

Conclusions

Using an anesthetic in a closed recirculating system is a safe and desirable procedure employed in the fin-marking of fingerling salmon and steelhead trout.

This procedure, with an anesthetic, has resulted in an overall improvement of the marking rate by 49.5 percent, as compared with previous procedures that did not include an anesthetic.

In addition to speed, several advantages are gained by using an anesthetic in the manner described in this report. The marks are better, the fish are less likely to be injured, the markers' fatigue is reduced, and time and money are saved.

Acknowledgments

The author wishes to express his sincere appreciation to Mr. T. B. McKee, who offered advice and assisted in preparing this report; to Mr. E. R. Jeffries, who suggested some of the methods used in this paper; and to Mr. Joe Wallis for assistance in constructing the apparatus.

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DIE ELECTROFISCHEREI (ELECTROFISHING)

H. W. Denzer
Handbuch der Binnenfischerei Mitteleuropas. Band 5, Lieferung 3,
233 pp., 127 illus., 49 tables.
E. Schweitzerbart'sche Verlagsbuchhandlung, Stuttgart. 1956.

Because of the growing importance of electrofishing, a modern handbook on the subject has been needed for some time. Here is a clear, understandable introduction to the theoretical and practical problems of electrofishing.

In addition to presenting stimulating suggestions for the future development of this type of fishing technique, the author of this handbook has reviewed the historical development of electrofishing. There is also a detailed description of the requirements for the use of this method of capture, as well as descriptions of the physiological effects of electrical curvent and the factors that regulate the responses of the fish in an electrical field.

The limitations of electrofishing are emphasized; and considerable space is allotted to the use of electrofishing equipment, including descriptions of a variety of European units. The author has outlined the methods and procedures of electrofishing as they apply to practical problems.

The book is well illustrated. Apparently it went to press before much of the recent work on the use of electricity in lamprey control in North America was published. In pointing out the most useful techniques and instruments, Dr. Denzer has chosen very carefully from the world literature.

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PROFESSIONALISM IN FISHERY BIOLOGY

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FIRM IN THE BELIEF that private, professional opportunities and rewards for fishery scientists need universal enhancement, Dr. Karl F. Lagler and Robert O. Beatty originally undertook this survey. The idea was to determine the extent to which the use of men in fisheries might be developed on a professional basis through servicing the owners of private fishing waters. In many areas of the country, for example, it was known to be impossible for private holders of water rights to secure the help which they needed and desired.

The procedure in this survey was to submit a questionnaire to chiefs of fishery departments in the 48 States during the fall of 1953. Also censused were a few private investigators who were known to be engaged periodically in consulting work.

The questions, a sense-summary of the replies, and a few illustrative quotations follow:

Is your department prohibited from providing direct help for the improvement of fishing to the owners of private waters?

About two-thirds of the States have no restrictions of this nature. The remainder are prohibited, either by law or by public pressure, from spending public money on private waters. A common expression in the replies was, "Our policy has always been to stay clear of private waters unless the owner agrees to leave the water open to public fishing."

How many requests do you receive each year for direct help on private waters involving other than routine requests which can be serviced permissably by mail?

The estimates ran from 10 to 4,000 requests, averaging about 50 per year. There seemed to be no correlation between the sizes of the States and the number of requests. The largest numbers were in the South and East. In one State it was felt that the number of requests received would be larger if people were aware of the service and its availability.

How many of these requests were you unable to meet?

These estimates ran from 0 to 100 percent, averaging about 50 percent. Here there was a large variation among the States, with no definite correlation between the number of requests and the percentage of requests which were not met.

Do private pond owners in your State have any other source of on-the-ground aid in their sportfishery management problems?

About half of the States replied, "Yes," listing the U. S. Soil Conservation Service as the major agency concerned. Also named were the U. S. Fish and Wildlife Service, county agents, a few private agencies, and some university professors and state biologists who consult--both free and for a fee--in their spare time.

Can you stock fish from State hatcheries in private waters?

About half the States can, though many have restrictions, as initial stocking only, warm-water fish only, etc. In some, private waters may be stocked if the public is allowed to fish; in others, stocking may be done in special cases only. Of States that permit planting public-owned fish in private waters, only one charges for the fish.

Do your personnel do on-the-ground survey or management work on private waters?

Three-quarters of the States answered, "Yes." Some were limited to farm ponds; some were limited as to extent of services they could render. Most of this work is done on State time, with no charge to the pond owner except where he paid for materials--poisons, fertilizer, etc.--used.

What services are requested or implied in such private-water requests?

SUMMARY OF SERVICES REQUESTED

Service requested	States having "few" requests	States having "many" requests
Installation of habitat improvement devices	22	1
Water-weed and/or algal control	13	26
Bait minnow production	15	15
Fertilization	18	14
Fish eradication or removal	16	20
Fish for stocking	8	28
Fish predator control	24	1
Mosquito control	13	2
Pond construction	17	10
Control of bad tastes or odors in water and/or fish	16	3
General improvement of fish (where a specific service is not requested)	16	19
Other: Fish kills from crop dusting	1	------
Commercial fish production	1	------
Leech	------	1

Most of the requests for service involved water-weed control, fish eradication or removal, fish for stocking, and general all-round appraisal, help, and guidance. From 19 to 28 States listed the foregoing as "many request" kinds of service; 10 to 15 assigned the "many request" classification to bait minnow production, fertilization, and pond construction.

Would you welcome a privately financed and operated sportfishery or management and consulting service, staffed by recognized and accredited biologists, operating only on private waters, and to which you could refer requests for help from private owners which you are unable to service to the fullest extent desirable?

About 80 percent answered, "Yes"; those that answered negatively qualified their replies. Some believed that the demand in their State was insufficient to warrant such a service. Two felt that the job should be done through their own departments; one believed that the biologists already doing part-time consulting would resent the competition.

If such a service were established on a nationwide basis and carefully operated so as not to conflict with or in any way duplicate or disturb fisheries or water-management policies or programs in your State, would you or members of your staff be willing to accept an occasional investigatory or management assignment, on own time, for fee plus expenses?

Two-thirds would like to participate in a program of this type. Many of those who replied negatively gave as reasons laws or departmental policies which would prohibit their participation. One felt that only full-time men should be used.

Guesstimate the number of private water owners in your State who might need such a service.

The answers ranged from 10 to 50,000, with the majority distributed between 50 and 5,000.

Guesstimate the number of private water owners in your State who might use such a service if offered at reasonable rates.

These estimates ran from 0 to 2,000, with most of them falling in the 10-pond to 100-pond range. Owing to the nature of the questions and the fact that only half of the States gave any estimates at all, it is doubtful that the preceding estimates are of much value.

By way of summary, do you feel that there is a place in the sportfishery and water-management picture today for a counseling and management service, following standard and accepted procedures and providing sound management programs for the owners of private waters?

About 90 percent thought that such a service would be beneficial. Those who dissented thought that the existing agencies should handle the job.

An affirmative statement of interest was: "Especially in heavily populated districts and around large cities where wealthy people are interested in private water leases and money is no object in the desire to improve fishing."

A negative comment was: "No, if our own service here can be expanded; yes, otherwise."

The most prevalent sense was: "A good management service would be wonderful, but even the people with money in their State expect the State and Federal government agencies to do it for them free."

Conclusions

Keeping in mind the limitations of a survey of this type, I believe that the following conclusions can be reached:

1. There is a need for professional fishery biologists who can give aid and advice to private pond owners.
2. In most areas a private consulting service would be welcomed by the State agencies concerned with fishery management.
3. The extent to which a service of this type would be profitable depends on the area concerned. In some areas competition with State agencies and the low potential market would eliminate a venture of this type. The data at hand indicate that the greatest opportunities lie in the eastern and southern portions of the United States.

As the fishing pressure increases on public waters, the growth of private professional opportunities for fishery scientists seems inevitable. From the data at hand, it appears that the time is ripe for the establishment of biological consulting services in the areas where the State agencies are not meeting the demands of the private water owners. It may be advisable for a special committee of the American Fisheries Society or the Sport Fishing Institute to undertake the establishment of codes of sound practice and recompense.

On the basis of laboratory tests, a sequentially pulsed array that has but a single row of electrodes appears to be a very promising means of diverting salmon fingerlings from dangerous areas at dams. Under the controlled conditions of the laboratory, a duty-cycle range from 0.06 to 0.10 has been effective in guiding these small fingerlings. To secure such a range, it is necessary to energize the electrodes only 6 to 10 percent of the time. As this low power requirement involves relatively low expenditures for electricity and for maintenance of equipment, there is reason to believe that guiding arrays thousands of feet in length would be feasible--and perhaps for all sizes of fingerlings.

WHO WANTS A BIOLOGIST ?
TWO YEARS OF PRIVATE CONSULTING SERVICE

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I HAVE NO INTEREST IN PERSONAL GAIN by presenting this brief paper. It is my desire to be helpful to others who may wish to know something about my experiences as a consulting biologist.

Consultants in various professions, such as chemistry and engineering, are common. The consulting biologist has had his shingle hanging out only within the past few years in America. True, biologists have done part-time consulting work; however, I refer specifically to full-time professional consultants.

In industrial and business circles, the consulting biologist at this time is little known and unappreciated. Industrialists who could use his services usually don't recognize that they have such needs and therefore do not seek such assistance where or when it is available in limited locations.

Who Wants a Biologist?

The "want" of this question is almost amusing. If the industrial and business world does not understand how the biologist might serve it, it really can't "want" a biologist--as paradoxical as this may sound.

The significant condition now in consulting biology is that the consultant must first sell himself, as well as sell the idea that he can serve. This is tough sledding when, at the outset, as in cases of industrial waste disposal problems, the industry rarely will admit that it has a problem (for various reasons), even if a biologist could help--and this the industry doesn't yet know!

For your information, I served as a consultant to industry in pollution problems, served in contamination litigation, assisted parks and other recreational organizations, conducted surveys for private lake and pond owners, aided water-supply companies, compiled facts for law firms and insurance agencies, assisted fish-and-pay lake owners, prepared popular fishing literature for various groups, conducted surveys on waters prior to industrial development, and so forth.

Hints for Success

In my varied experience I learned that the following conditions apparently contribute to your success or failure:

1. A consultant without independent financial resources has a tough time of it. A silent partner helps. A side-line job helps if it does not require too much time; and even so, it should be avoided lest it detract from your primary job.

The pioneer consultant finds, I noted, that his income graph forms "chocolate drop" curves. It's nice when the curves go up, but there are equal numbers of

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This paper was presented at the conference of the Northeast Sections of the Wildlife Society; American Fisheries Society; Conservation Law Enforcement Chiefs; and Fish, Game, and Conservation Commissioners at Pittsburgh, Penna., May 14-16, 1956.

downs. This is because you can't always (especially working alone) be setting up the next project while on an assignment away from your office some several hundred miles! When you get home you soon learn that, as you prepare your current project report, you have to start worrying about the next assignment--and it may not materialize as soon as you had anticipated, and sometimes not at all.

2. You have to have lots of what my mother used to call "git up"! Unless you have the best financial backing, you can't relax one bit. That monthly pay check you once had would be handy (unless you have good retainers) but isn't there.

3. Extensive travel is essential in a young consulting field. You have to broaden your scope of types of assignments, as well as territory, to get adequate business. Travel would be more comfortable and less time-consuming by train or plane, but the consulting biologist has to travel by car or station wagon simply because he must haul much bulky and heavy gear in order to conduct aquatic surveys, regardless of type.

4. The established field of sanitary engineering is in many instances hindering the progress of the consulting aquatic biologist. Few professional sanitary engineers will admit that the aquatic biologist is a necessary man, and they often feel that their one course in bacteriology qualifies them to represent industries and municipalities in the biological sciences.

5. Free service has been given to the public and industry for many years by State and Federal agencies, as well as by university biologists. Industry actually prefers to pay for professional services; however, it has been using the free service because that has been the only type available for many years.

6. You have to have the ability to deal with business executives (not technical men), else you are lost.

The Future

I feel that consulting biologists of all types, including the aquatic biologist, will do well in the next 5 years. A few of us, such as are represented here today, have broken lots of ice for future aspirants. It is my feeling that business men will eventually recognize our shingle and call for our services.

The best parallel is landscape architecture and gardening. At one time I personally used to be amused at the idea of anyone's hanging out a sign indicating that he was available to tell you how to plant trees and shrubs around your house or factory. (Something folks had been doing themselves for years!) Today this particular field has grown and is recognized, and business often pays well for this special professional service. Consulting foresters in some sections passed through this phase of development.

I hope other consulting biologists can stick it out better than I. Personally, I enjoyed the field; however, I chose to spend more time at home with my family rather than to beat the bushes over 20 States on jobs and on the search for new assignments. One of these days the consulting biologist may be able to develop an adequate number of clients so that he will be able to stick close to one given metropolitan area.

The field is a lucrative one, and I feel that the consulting biologist may prove very helpful in increasing salaries of all biologists in governmental fields merely because of comparative values of worth in industrial lines.

A laboratory concentration of Gymnodium brevis (red-tide organism) had about 3 million individuals per quart. With the addition of juices of fish killed experimentally by a relatively low concentration of G. brevis, the number of individuals tripled overnight.

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